

**TWO-ENTRY LONGWALL MINING SYSTEMS
A TECHNICAL EVALUATION**

**PREPARED FOR
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**BY
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ACKNOWLEDGMENTS

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- THE HOSPITALITY EXTENDED BY THE OPERATORS OF THE MINES VISITED;
- THE COOPERATION OF THOSE OPERATORS AND OF THE LOCAL LABOR REPRESENTATIVES WHO SUPPLIED MUCH VALUABLE INFORMATION;
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EXECUTIVE SUMMARY

AS A RESULT OF QUESTIONS CONCERNING THE 2-ENTRY LONGWALL MINING SYSTEM, THE ASSISTANT SECRETARY OF LABOR FOR MINE SAFETY AND HEALTH DIRECTED THAT A TASK FORCE BE ESTABLISHED TO STUDY THE 2-ENTRY SYSTEM. THE TASK FORCE WAS CONVENED BY THE DIRECTOR FOR TECHNICAL SUPPORT WITH ASSISTANCE FROM THE ADMINISTRATOR FOR COAL MINE SAFETY AND HEALTH.

THE TASK FORCE HELD ITS FIRST MEETING ON JANUARY 28, 1985, IN DENVER, COLORADO. AT THIS MEETING, THE TASK FORCE WAS DIRECTED TO STUDY ALL COMMONLY EMPLOYED PRACTICES AND EQUIPMENT USED IN LONGWALL MINING AND ANY EFFECT ON A MINER'S SAFETY OR HEALTH WHICH MAY ACCOMPANY THESE PRACTICES OR EQUIPMENT IN A 2-ENTRY SYSTEM. SPECIFIC RECOMMENDATIONS CONCERNING SAFETY OR HEALTH PROBLEM AREAS WHICH THE EVALUATION MAY DISCLOSE WERE REQUESTED.

TO ACCOMPLISH ITS OBJECTIVES, THE TASK FORCE ORGANIZED INTO STUDY GROUPS TO EVALUATE GROUND CONTROL PRACTICES, VENTILATION REQUIREMENTS, ELECTRICAL PRACTICES, FIRE HAZARDS/FIRE SUPPRESSION ASSOCIATED WITH EQUIPMENT, AND ENVIRONMENTAL MONITORING SYSTEMS AVAILABLE TO THE MINING INDUSTRY.

AS THE STUDY GROUPS PREPARED THEIR WORK PLANS, IT BECAME OBVIOUS THAT SOME GUIDELINES, IN ADDITION TO THE STATED OBJECTIVES, WERE NECESSARY. THE TASK FORCE, THEREFORE, ADOPTED PRECEPTS WHICH FOUNDED ITS DECISIONS ON TECHNICAL CRITERIA AND EXISTING TECHNOLOGY; LIMITED ITS REVIEW TO LONGWALL PANELS AND ASSOCIATED EQUIPMENT; EXCLUDED DRAFTING PROPOSED REGULATIONS AND ECONOMIC IMPACT STUDIES; PROHIBITED

THE AUDITING OF ENFORCEMENT PRACTICES WITHIN THE VARIOUS DISTRICTS VISITED; AND REQUIRED FIELD EVALUATIONS AT ALL AVAILABLE MINES CURRENTLY OPERATING 2-ENTRY LONGWALL PANELS AND OTHER MINES OPERATING LONGWALLS AT DEPTHS GREATER THAN 1000 FEET.

AS PART OF ITS INFORMATION GATHERING PROCESS, THE TASK FORCE IDENTIFIED 11 MINES CURRENTLY MINING OR DEVELOPING LONGWALL PANELS WITH THE 2-ENTRY TECHNIQUE. OF THESE, 7 MINES WERE VISITED. FOR COMPARISON PURPOSES, 2 MINES USING 3-ENTRY PANELS AND 5 MINES USING 4-ENTRY PANELS AT DEPTHS IN EXCESS OF 1000 FEET WERE ALSO VISITED. ON-SITE, DATA GATHERING VISITS WERE CONDUCTED AT ALL MINES DURING FEBRUARY AND MARCH 1985. SEVERAL 101(c) PETITIONS FOR 2-ENTRY DEVELOPMENT AND LONGWALL MINING WERE ALSO RECEIVED AND REVIEWED.

AS THE LAST STEP IN THE INFORMATION GATHERING PROCESS, A PUBLIC MEETING WAS HELD IN GOLDEN, COLORADO ON MARCH 12, 1985. REPRESENTATIVES OF TWO MINING ASSOCIATIONS, EIGHT MINING COMPANIES; TWO CONSULTING ENGINEERING FIRMS; THE UNITED MINE WORKERS OF AMERICA (INTERNATIONAL); AND EIGHT MEMBERS OF THE UNITED MINE WORKERS OF AMERICA SPOKE AT THE MEETING. IN GENERAL, MINING COMPANIES AND THEIR CONSULTING ENGINEERS SPOKE IN FAVOR OF THE 2- ENTRY TECHNIQUE, WHILE UNION REPRESENTATIVES SPOKE AGAINST. APPROXIMATELY 100 PEOPLE ATTENDED THE MEETING.

AFTER A THOROUGH ANALYSIS OF TECHNICAL DATA, REVIEW OF AVAILABLE "BUMP" AND ROOF FALL RECORDS, EXTENSIVE REVIEW OF IN-MINE CONDITIONS, AND DELIBERATIONS AMONG ALL TASK FORCE MEMBERS, THE TASK FORCE

CONCLUDED THAT THE 2-ENTRY TECHNIQUE FOR DEVELOPING LONGWALL PANELS CAN BE A JUSTIFIABLE MINING PROCEDURE. THE TASK FORCE, HOWEVER, RECOGNIZES THAT EMERGENCY EVACUATION IS LIMITED WHEN USING THIS TECHNIQUE AND, THEREFORE, RECOMMENDS THAT IT BE PERMITTED ONLY AFTER THE SAFEGUARDS CONTAINED IN THIS REPORT HAVE BEEN CONSIDERED.

TASK FORCE OBJECTIVE

"THE COMMITTEE IS TASKED WITH EVALUATING ALL COMMONLY EMPLOYED PRACTICES AND EQUIPMENT USED IN LONGWALL MINING AND ANY EFFECT ON MINER SAFETY WHICH MAY ACCOMPANY THESE PRACTICES OR EQUIPMENT IN A TWO-ENTRY LONGWALL SYSTEM. WHEN POSSIBLE, COMPARISONS BETWEEN TWO-ENTRY AND THREE OR MORE ENTRY SYSTEMS SHOULD BE MADE. SPECIFIC RECOMMENDATIONS CONCERNING ANY SAFETY PROBLEM AREAS WHICH YOUR EVALUATION MAY DETERMINE ARE REQUIRED.

THE COMMITTEE IS SPECIFICALLY DIRECTED BUT NOT LIMITED TO EVALUATING EQUIPMENT AND PRACTICES IN THE FOLLOWING GENERAL AREAS AS THEY APPLY TO MULTIPLE ENTRY LONGWALL MINING SYSTEMS:

GROUND SUPPORT

VENTILATION

ELECTRICAL

FIRE HAZARDS/SUPPRESSION

FIRE DETECTION"

MSHA TASK FORCE ON LONGWALL MINING

CHAIRMAN

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FIRE DETECTION STUDY GROUP

KEVIN L. HEDRICK, ELECTRICAL ENGINEER, A&CC (GROUP LEADER)

ELIO L. CHECCA, ELECTRICAL ENGINEER, BSTC

A&CC : APPROVAL AND CERTIFICATION CENTER - MSHA

BSTC : BRUCETON SAFETY TECHNOLOGY CENTER - MSHA

CMS&H : COAL MINE SAFETY AND HEALTH - MSHA

DS&HTC : DENVER SAFETY AND HEALTH TECHNOLOGY CENTER - MSHA

PHTC : PITTSBURGH HEALTH TECHNOLOGY CENTER - MSHA

BOM-DRC: BUREAU OF MINES - DENVER RESEARCH CENTER

TASK FORCE ADOPTED PRECEPTS

1. TECHNICAL CRITERIA AND EXISTING, AVAILABLE TECHNOLOGY WILL BE USED AS THE FIRST BASIS FOR EVALUATIONS, CONCLUSIONS, AND RECOMMENDATIONS. MINING PRACTICES AND SYSTEMS WILL THEN BE REVIEWED TO DETERMINE THEIR ABILITY TO COMPLY WITH EXISTING REGULATIONS.
2. ALTHOUGH MANY OF THE PRACTICES AND TECHNIQUES REVIEWED BY THIS TASK FORCE MAY BE APPLICABLE TO ROOM AND PILLAR MINING IN ADDITION TO LONGWALL MINING, THE TASK FORCE WILL LIMIT ITS REVIEWS TO LONGWALL PANELS AND EQUIPMENT COMMONLY USED ON LONGWALL PANELS.
3. ALTHOUGH IT IS RECOGNIZED THAT THE TASK FORCE'S RECOMMENDATIONS MAY BECOME THE BASIS FOR FUTURE POLICY OR REGULATORY DECISIONS, THE TASK FORCE WILL NOT FORMULATE PROPOSED POLICIES OR REGULATIONS.
4. THE TASK FORCE WILL NOT AUDIT ENFORCEMENT PRACTICES WITHIN THE VARIOUS MSHA ENFORCEMENT DISTRICTS VISITED.
5. ALTHOUGH DATA COLLECTED BY THE TASK FORCE COULD BE USEFUL IN DEVELOPING ECONOMIC STUDIES, NO ECONOMIC IMPACT STATEMENT WILL BE PREPARED.
6. FIELD EVALUATIONS WILL BE CONDUCTED AT MINES OPERATING AT DEPTHS GREATER THAN 1000 FEET AND AT MINES UTILIZING 2-ENTRY DEVELOPMENT AT A SHALLOWER DEPTH.

7. ALL OPERATING MINES UTILIZING 2-ENTRY LONGWALL PANEL DEVELOPMENT WILL BE VISITED.
8. A SAMPLE OF MINES UTILIZING 3- OR 4-ENTRY DEVELOPMENT FOR LONGWALL PANELS AT DEPTHS EXCEEDING 1000 FEET WILL BE VISITED FOR COMPARISON PURPOSES.
9. IF SUFFICIENT EVIDENCE IS FOUND TO RECOMMEND RETENTION OF 2-ENTRY DEVELOPMENT MINING, SAFEGUARDS TO COMPENSATE FOR THE REDUCED NUMBER OF ENTRIES SHALL BE CONSIDERED. THE PRIORITY FOR THESE SAFEGUARDS, WITH REGARD TO MINE FIRES, SHALL BE:
(1) FIRE PREVENTION; (2) FIRE DETECTION/CONTROL; (3) EVACUATION.

PUBLIC MEETING ON TWO-ENTRY LONGWALL MINING SYSTEMS
MARCH 12, 1985 - GOLDEN, COLORADO

LIST OF SPEAKERS

ASSOCIATIONS (2):

AMERICAN MINING CONGRESS - JOEL A. STRID, CHAIRMAN, INDUSTRY
TASK GROUP ON TWO-ENTRY MINING SYSTEMS
COLORADO MINING ASSOCIATION - PATRICK HARVEY, VICE-CHAIRMAN FOR
HEALTH AND SAFETY

OPERATING COMPANIES (8):

CARBON COUNTY COAL COMPANY - DON ROUTON, CHIEF ENGINEER
PRICE RIVER COAL COMPANY - GORDON COOK, VICE PRESIDENT AND
GENERAL MANAGER
KAISER STEEL CORPORATION - BRETT HARVEY, GENERAL MANAGER
PLATEAU MINING COMPANY - WALTER MUELLER, JR., VICE PRESIDENT AND
GENERAL MANAGER
MID-CONTINENT RESOURCES, INC. - JOHN REEVES, PRESIDENT
EMERY MINING COMPANY - BILL ZELLER, EXECUTIVE VICE-PRESIDENT AND
GENERAL MANAGER
SOUTHERN UTAH FUELS COMPANY - KENNETH PAYNE, VICE PRESIDENT AND
GENERAL MANAGER
UTAH FUELS COMPANY - GLEN ZENWALD, GENERAL MANAGER

CONSULTING ENGINEERS (2):

J.F.T. AGAPITO AND ASSOCIATES - JOSEPH AGAPITO
ROBERT G. HEERS, CONSULTING ENGINEER - ROBERT HEERS

UNITED MINE WORKERS OF AMERICA (INTERNATIONAL) (3):

DAN DAVIDSON, ASSISTANT ADMINISTRATOR, DEPT. OF OCCUPATIONAL
HEALTH AND SAFETY
ALONZO MULLINS, SAFETY INSPECTOR, UMWA DISTRICT 8
WALTER OVAITT, INTERNATIONAL SAFETY REPRESENTATIVE FOR UTAH,
WYOMING, AND COLORADO

UNITED MINE WORKERS OF AMERICA (8):

LOCAL No. 7949 (YORK CANYON MINE) - ABEL JIRON, VICE PRESIDENT
MIKE FRESQUEZ, MEMBER
DANNY GALLEGOS, CHAIRMAN, SAFETY COMMITTEE
TOM ALDERETTE, PRESIDENT
GARY DECKER, MEMBER

LOCAL No. 2123 (PRICE RIVER #5) - JAMES GILSON, SAFETY COMMITTEE
CHAIRMAN

LOCAL No.* (WILBERG MINE) - RON CARPENTER, MEMBER

DISTRICT 15 (YORK CANYON MINE) - PAT PETTERIN

REGISTERED BUT DID NOT ATTEND (1):

COAL EMPLOYMENT PROJECT - Ms. JOY HUITT

*LOCAL NOT IDENTIFIED.

CONCLUSION

SUFFICIENT TECHNICAL AND HISTORICAL DATA HAVE BEEN REVIEWED AND EVALUATED TO ESTABLISH THE 2-ENTRY LONGWALL PANEL DEVELOPMENT TECHNIQUE AS A JUSTIFIABLE MINING PROCEDURE. THE 2-ENTRY TECHNIQUE, UNDER ADVERSE GEOLOGIC CONDITIONS, HAS REDUCED THE OCCURRENCE OF PRESSURE "BUMPS," ROOF FALLS, AND OTHER GROUND CONTROL PROBLEMS DURING MINING OPERATIONS. THE TASK FORCE, HOWEVER, RECOGNIZES THAT EMERGENCY EVACUATION IS LIMITED BY THIS TECHNIQUE AND, THEREFORE, RECOMMENDS THAT IT BE PERMITTED ONLY AFTER THE SAFEGUARDS CONTAINED IN THE RECOMMENDATIONS SECTION OF THIS REPORT HAVE BEEN CONSIDERED.

GENERAL RECOMMENDATIONS

1. ADMINISTRATIVE CONTROLS - REGULATORY CONTROL OF 2-ENTRY LONG-WALL MINING IS NECESSARY. DUE TO THE LIMITED EGRESS PROVIDED BY THE 2-ENTRY TECHNIQUE, SAFEGUARDS TO ENSURE MINER SAFETY AND HEALTH MUST BE PROVIDED. SAFEGUARDS RECOMMENDED WITHIN THIS REPORT SHOULD BE CONSIDERED DURING THE DESIGN, PROPOSAL, AND REVIEW OF 2-ENTRY LONGWALL SYSTEM MINE PLANS. AT PRESENT, CENTRALIZED APPROVAL/DISAPPROVAL OF ALL NEW 2-ENTRY SYSTEMS VIA THE 101(c) PETITION FOR MODIFICATION PROCESS APPEARS TO BE THE MOST APPROPRIATE PROCEDURE FOR MAINTAINING REGULATORY CONTROL.

2. TRAINING

- (A) INDUSTRY, LABOR ORGANIZATIONS, AND MSHA SHOULD INTENSIFY INDIVIDUAL EFFORTS AND COOPERATION TO INCREASE THE GENERAL LEVEL OF KNOWLEDGE AND ABILITY TO PROMOTE PROPER ELECTRICAL PROCEDURES AND PRACTICES IN COAL MINES. IN GENERAL, CONDITIONS OBSERVED INDICATED A NEED TO IMPROVE THE QUALITY OF ELECTRICAL WORKMANSHIP AND INSTILL A DESIRE FOR GOOD HOUSEKEEPING PROCEDURES. THIS CAN BEST BE OBTAINED THROUGH A CONCENTRATED TRAINING EFFORT.
- (B) INDUSTRY, LABOR ORGANIZATIONS, AND MSHA SHOULD INTENSIFY INDIVIDUAL EFFORTS AND COOPERATION TO INCREASE THE GENERAL LEVEL OF KNOWLEDGE AND ABILITY OF UNDERGROUND MINERS TO RESPOND TO EMERGENCY SITUATIONS.

3. LONGWALL REGULATIONS - STANDARDS SPECIFIC TO LONGWALL MINING SHOULD BE ADOPTED BY MSHA. WITH THE CURRENT LIMITED APPLICABILITY OF SOME EXISTING STANDARDS AND THE ABSENCE OF STANDARDS IN CRITICAL AREAS (I.E. TAILGATE EGRESS), CONSIDERATION SHOULD BE GIVEN TO DRAFTING STANDARDS SPECIFICALLY APPLICABLE TO LONGWALL MINING. THIS RECOMMENDATION IS NOT INTENDED TO CALL FOR THE WRITING OF AN ENTIRE SECTION OF STANDARDS FOR LONGWALL MINING, BUT RATHER THAT FORMULATION OF SOME REGULATIONS TO ADDRESS SPECIFIC AREAS OF CONCERN WHERE CHANGING MINING TECHNOLOGY HAS LEFT REGULATORY UNCERTAINTY.
4. SELF-CONTAINED SELF-RESCUERS (SCSR's) - ADDITIONAL RESEARCH SHOULD BE UNDERTAKEN TO DEVELOP MORE COMPACT, LIGHTER, AND MORE SERVICEABLE SELF-CONTAINED SELF-RESCUERS. ANY REDUCTION IN SIZE OR WEIGHT OF THE SCSR WITHOUT SACRIFICE OF RELIABILITY OR LIFE-SUPPORT FUNCTION WOULD PROMOTE A MORE POSITIVE ATTITUDE TOWARD THE UNIT AND ENHANCE ITS ACCEPTANCE.
5. ENVIRONMENTAL MONITORING - CURRENTLY AVAILABLE MONITORING EQUIPMENT CAN PROVIDE EARLY WARNING OF FIRES IN THEIR INCIPIENT STAGES AND METHANE BUILD-UP IN LOW CONCENTRATIONS, YET USE OF THIS EQUIPMENT IS NOT WIDESPREAD. THE TASK FORCE, THEREFORE, RECOMMENDS THAT THE MINING INDUSTRY MAKE GREATER EFFORTS TO FAMILIARIZE ITSELF WITH THIS AVAILABLE TECHNOLOGY AND THAT THIS EQUIPMENT BE USED TO PROMOTE THE SAFETY AND HEALTH OF THE MINING COMMUNITY.

GROUND CONTROL STUDY GROUP

Abstract

The Ground Control Study Group focused its efforts on ground control problems, practices, and associated stability related to the development and retreat of longwall panels utilizing 2-entry systems under both deep and shallow cover and multiple entry systems¹ under deep cover. Only currently operating United States mines were considered in the evaluation.

In all, the group visited 14 mine sites, and met with mine operators to gather information relative to their mining experiences. Special emphasis was placed on bump-bounce-burst and roof fall history, and pillar or floor failures, both in 2-entry and multiple-entry development and retreat panels. Underground portions of each mine were examined to establish the nature of existing ground conditions and the effectiveness of mine design and support techniques. Particular attention was devoted to ground stability in 2-entry and multiple-entry development sections, gateroad stability on active longwall panels, conditions in bleeder entries, the effectiveness of roof support systems in use, and roof-fall rehabilitation methods used in the gateroads. In addition, the group reviewed and analyzed roof control plans, petitions for modification (2-entry systems), roof fall and accident data, and technical literature related to the rock mechanics aspects of longwall mining.

Based on the historical data gathered, underground observations, technical literature review, and a rock mechanics evaluation by the group, the Ground Control Study Group has concluded that 2-entry systems can provide improved ground stability and safety in many difficult mining situations, and should be considered as a viable alternative in longwall mining.

¹See Appendix A.

MECHANICS OF GROUND CONTROL IN LONGWALL MINING

The subject of ground control is very complex. Stability in coal mines is influenced by a wide range of factors which, to name only a few, include geology, overburden, rock and coal properties, and mine layout. Because of these variations, techniques that work in one mine fail miserably in another. In essence, ground control remains an art, justified theoretically by sound rock mechanics principles, but founded primarily on past experience and by "what works."

Over the years, it has been established that, despite variation in conditions, the less territory opened up; the fewer ground stability problems encountered. At the risk of oversimplifying the process, two fundamental concepts can be used to illustrate the ground control benefits attained through the mining of fewer entries on developing sections.

1. Pressure Arch Theory - The stress level experienced by development systems is usually a direct function of the panel width and the number of entries. When a group of entries is developed, the overburden weight previously supported by the coal extracted is transferred to the coal pillars adjacent to the openings, and equilibrium is achieved. With the passage of time, the pillars yield and a portion of the overburden weight is transferred laterally to the solid coal adjacent to the panel. Highly-stressed zones are thus created, and the magnitude of the abutment stresses are directly proportional to the panel width. Additionally, the amount of

overburden (within the pressure arch) carried by the internal panel pillars is also a function of the panel width. Under extreme conditions—such as deep cover, bump prone strata, weak roof or floor—minimization of the stress level is essential to ground stability.

2. Intersections - A more direct demonstration of the impact of the number of entries on ground control safety can be generated through an evaluation of intersections contained in various panel geometries. In general, roof falls are more likely in intersections than in areas between intersections and 4-way intersections are more critical than 3-way intersections. From strictly a viewpoint of probability, panels containing fewer intersections are less likely to experience roof falls. Two-entry developments contain 33 percent fewer intersections than 3-entry systems, 50 percent fewer than 4-entry panels, and no 4-way intersections at all. In essence, the exposure of miners to potential roof falls (still the number one killer of miners underground) can be reduced by limiting the number of development headings for longwall panels.

The stability of gateroads during the longwall retreating process is much more complex and difficult to generalize. Numerous and often conflicting design methods exist regarding headgate and tailgate entry configurations. Similarly, the results of analytical studies provide conclusions that, under varied mining conditions, may be contrary to what is observed underground. In essence, the complexities of mining conditions often preclude the use of a standard design criterion. Controlling the ground around the highly stressed

tailgate area is essential, regardless of conditions. Two general approaches can provide insight into the critical area of tailgate stability in the most general sense.

The first utilizes the techniques of isolating the tailgate from the gob area through a multiple-entry configuration, or a 2-entry system with a single infinitely-strong pillar. This method uses the gate-road pillar(s) to absorb the abutment stress and protect the outside headgate entry that will serve as the next tailgate. In many mine applications this method has been successful, and excellent tailgate stability has resulted. In others, however, bumps, bounces, roof falls and extreme heave in the tailgate have occurred. In those cases, it has been theorized that the high load carried by the chain pillars contributed to the deteriorating conditions in the tailgate entry.

The second approach to stable tailgates attempts to force the majority of the abutment stress to locate on solid coal, thus bypassing the tailgate itself. The utilization of 2-entry systems with small (yielding) pillars in this manner has often resulted in dramatic improvements in stability when extreme mining conditions were encountered. By reducing the total load carried by the chain pillars, substantial reductions in bumps, roof falls, and floor heave have been realized.

The preceding simplified explanations of gateroad stability barely scratch the surface of the overall mechanism but provide some insight into design considerations. The optimum dimensions and number of chain pillars separating

adjacent gobs vary widely with mining conditions. In practice, mining companies use various configurations of yielding pillars, stable pillars, or combinations of the two, dependent upon local ground conditions. The 2-entry gateroad system has evolved as a viable configuration that can be used under extreme mining conditions in which multiple entries fail.

GENERAL FINDINGS

The 14 mines visited can be categorized into four distinct groups:

1. 2-entry development systems under deep cover with bounce and bump-prone conditions,
2. 2-entry development systems under shallow cover with roof fall problems,
3. 3-entry development systems under deep cover,
4. 4-entry development systems under deep cover.

The following discussion will generalize the findings of mines visited in the various categories.

Two-Entry Systems: Bump/Bounce-Prone Conditions--Deep Cover

The five mines visited in this group contained several common characteristics:

- extremely deep cover (1,500 feet to 3,000 feet)
- steeply pitching seams (10 to 15 percent)
- energy-storing coal
- massive, "cliff-forming" roof
- hard bottom
- multiple-seam mining

In general, all had been plagued with catastrophic bounce/bump and roof-fall problems when multiple-entry systems, regardless of configuration, were developed or retreated. Numerous fatalities and injuries had occurred at these mines prior to the implementation of 2-entry longwall mining. One operation (two mines) reported 21 fatalities with multiple-entry room-and-pillar mining in the 15 years prior to the adoption of the 2-entry longwall method. In the 25 years since, one ground-control-related fatality has occurred and severe bump/bounce occurrences have been reduced to one-tenth their former rate. Roof-fall-related accidents at another mine have been reduced to about one-half their former rate since adoption of the 2-entry longwall method.

All room-and-pillar mining has been abandoned at these mines. Past attempts at longwall mining with multiple-entry (three or more) gateroads at all five mines have also been unsuccessful, whether utilizing large or yielding-type pillars. As suggested previously by the theoretical analysis, under the extreme conditions in which these mines operate, a 2-entry gateroad design appears to limit the stress interaction and provides for a more stable mining environment as attested by the bump/bounce, roof fall, and injury/fatality history.

Two-Entry Systems--Shallow Cover

The two mines in this classification are categorized by several common points:

- shallow cover (100 to 900 feet)
- no bump/bounce problems
- general roof fall problems

While ground conditions were not severe at any of these mines, substantial reductions in the roof fall rates were realized in all cases when 2-entry gateroads were developed. The reduction was approximately 2 to 1 in 2-entry versus 3-entry systems and greater when compared to four or more entries. Usually, both the roof and pillars appeared more stable when two entries were utilized in all the mines. Once again, as theory would suggest, the lower stress fields and reductions of intersections in 2-entry systems have led to improved ground conditions.

Three-Entry Systems--Deep Cover

Only two mines utilizing 3-entry gateroads were visited, with the following common traits:

- deep cover (up to 2,000 feet)

- no bump/bounce problems

In all other aspects, ground conditions varied substantially. Conditions in one mine (high coal and pitching) were severe, as numerous roof falls in multiple-entry developments were common. Maintaining gateroads open was difficult as severe bottom heave (aggravated by 4 to 6 feet of bottom coal left in place) rode out cribs, rendering the supplemental support ineffective. This operator has documented a reduction in roof falls in 3-entry panels, when compared to 4- or 5-entry systems of about 2 to 1. Further improvement was apparent with limited 2-entry development in setup rooms.

In the other mine, when a panel of 14 main entries were driven under 1,600 feet of cover, a severe squeeze was encountered forcing withdrawal from the area. By subsequently developing mains in groups of four entries, stability

has been maintained in areas of deep cover. Ground conditions throughout the remainder of the mine were generally excellent as the firm roof and bottom were well controlled in 3-entry longwall panels and in the mains. Again, limiting the number of panel entries can reduce both stress fields and intersections, and lead to improved ground stability.

Four-Entry Systems--Deep Cover

Five 4-entry mines were visited with the following similar conditions:

- deep cover (1,000 to 2,500 feet)
- nominal roof stability problem
- severe floor heave problems

Few roof fall problems existed in any of the mines because of the firm nature of the roof strata. In general, the primary problem experienced was severe bottom heave in the tailgate entries of longwall panels. Each of the mines has experimented with a wide variety of chain pillar designs, with limited success, in an effort to alleviate the heave encountered. One mine had also experienced severe bump problems in an area where hard bottom was encountered. A manipulation of yield and stable pillars appeared to reduce the bump potential in that area. Each operator had given consideration to utilizing 2-entry gateroads but, because of the extreme gassiness of these mines and ventilation difficulties, their use was precluded. In essence, novel pillar design methods have reduced the bump potential and heave problems in these mines where difficult mining conditions were encountered.

SUMMARY OF FINDINGS

The preceding discussions have outlined the information-gathering process utilized by the Ground Control Study Group and touched briefly upon relevant rock mechanics theory and highlighted key aspects of the mine site investigations. As was noted previously, the overall study included extensive literature searches, detailed mine investigations, and discussions with industry personnel which resulted in the accumulation of a wealth of relevant material. Based on that information, the following generalized findings were identified as pertinent.

- Mining and geologic conditions throughout the country are extremely varied and complex, and no single design method can apply to all mines.
- Substantial reductions in the occurrence of bumps/bounces and roof falls during development can be realized by limiting the width of span and number of entries in mains, gate roads, and bleeders.
- Stability can be maintained through the use of multiple-entry systems (3+ entries) on longwall panels, even under deep cover, when normal ground conditions, such as firm roof and floor with no bumping tendencies, prevail.
- In many cases, bump/bounce, roof fall, and heaving problems associated with multiple-entry (3+ entries) longwalls under difficult conditions (such as soft floor, weak roof, or bumping strata) can be alleviated through innovative pillar design methods.
- Under extreme mining conditions, where catastrophic and violent bounces, bursts, and floor heave are common, and where multiple-entry systems (3+

entries) have not been effective, 2-entry gateroads, utilizing both yielding or stable pillars, have provided increased stability on long wall panels with substantial reductions in the occurrence of bumps/bounces, roof falls, and floor heave.

--A number of the operators of multiple-entry longwalls visited expressed a desire to attempt mining with 2-entry gateroad systems to improve ground stability but, because of methane liberation and ventilation difficulties inherent in low seam mines, they do not consider this technique viable for their operations.

--The effects of the frontal abutment stress associated with the mining of longwall panels was evident in all of the mines visited. Pillar sloughing, floor heave, and roof deterioration (of varying degrees) were evident in both the headgate and tailgate entries at distances up to 150 feet in advance of the face dependent upon depth of cover and the nature of the strata. Optimum ground stability can be achieved in these areas by providing support before the ground is affected by the overriding stresses.

--General roof support methods in the headgate entry included a row of either hydraulic or wooden props adjacent to the stage loader, timbering off of the first crosscut outby the face with posts or cribs and supplemental bolts or trusses as needed, in addition to the normal roof bolts installed on development.

--Tailgate entry supports (in addition to development supports) generally consisted of either a single or double row of wood or fibercrete cribs along its length with posts and roof trusses as needed. Such supplemental support was usually installed in the tailgate anywhere from 50 feet to 200 feet ahead of the previous longwall face as it was retreated.

--Because of the high stress levels encountered, roof falls and other ground failures in tailgate entries were generally large scale. Rehabilitation of these areas was made difficult by limited access to the failed zones through the tailgate entries and compounded by the placement of cribs and other supplemental supports which restrict cleanup activities. The rehabilitation of tailgate ground failures could be greatly enhanced by giving consideration to the design and placement of supplemental supports relative to the size and type of cleanup equipment used for such purposes.

--Operators of 2-entry systems felt it necessary to maintain the tailgate open as a travelway off the longwall face and indicated a commitment to keeping it passable even if hand loading were required to clean up a roof fall, or the panel would be abandoned.

--Operators of multiple-entry systems did not place the same emphasis on keeping the tailgate open; often feeling it was a greater hazard to expose miners to the unstable conditions during cleanup than simply mining by a roof fall.

--In general, better ground stability was achieved in bleeder entries when they were separated from mined-out panels by barrier pillars, although a well-designed multiple-entry system could also be effective.

VENTILATION STUDY GROUP

Abstract

The ventilation practices utilized on longwall panels during both development and retreat mining were investigated. Of particular interest to the Study Group were:

1. General ventilation practices
2. Respirable dust control practices
3. Ventilation of conveyor belt haulageways
4. Escapeway integrity and location including other potential escape routes
5. Ventilation of electrical installations
6. Gob ventilation and bleeder systems
7. SCSR storage

Based on the results of underground investigations, the Ventilation Study Group has identified several areas of concern which may require additional safeguards and/or modification of existing practices. Included in these areas of concern are escapeways, storage of SCSR's, use of air in belt haulageways for ventilating active working places, use of diesel equipment, and bleeder entries.

Additionally, the study group has identified other areas of concern common to all longwall mining where existing practices could be augmented to provide an enhanced level of safety and/or improve the mining environment. Included in this category are tailgate entries, ventilation of electrical installations, ventilation of belt haulage entries, ventilation of longwall faces for dust control, and general ventilation practices on development sections.

GENERAL FINDINGS

1. Although no in-depth ventilation or dust surveys could be performed and only spot checks at the most important locations could be attempted, the primary ventilation systems in the working areas visited appeared to be adequate.
2. Tailgate Entries
 - A. Two-entry systems - All tailgates were open and travelable during the Group's visit, however, one mine reported a recent occasion when the tailgate entry was blocked by a roof fall until such time as the longwall had been advanced past the fall location.
 - B. Three-entry systems - In these mines, travel in the tailgate entry was possible, however, access to this entry from the longwall face was blocked by a fall and bad top in one mine. This same longwall had also just been advanced past a fall in the tailgate.
 - C. Four-entry systems - In all four mines with longwalls, travel in the tailgate entry was possible; however, in some cases, roof and floor convergences made travel difficult. In one mine, access to the tailgate entry was severely restricted by loose coal.
 - D. In all mines, regardless of the number of entries developed, airflow in the tailgate entry was restricted by roof falls, rib sloughage, floor heave, and/or supplemental roof support such as cribs. Air quality in these entries was found to be acceptable except at one mine where the methane content was found to be 1.5 percent.

3. Belt Entries - Developments

- A. Two-entry systems - Belts were installed in the return aircourse with monitoring systems at the two mines where development entries were being driven. These mines monitored both carbon monoxide and methane in the belt/return aircourse. Reportedly, at the other five mines using a two-entry system, two used monitoring systems and three did not.
- B. Three-entry systems - At the two mines using the three-entry system, the belts were ventilated with a separate split of intake air directed away from the face. None of these mines utilized a monitoring system.
- C. Four-entry systems - All five mines visited used air which traveled in the belt haulage entry to ventilate active working places. With one exception, all mines monitored the air in the belt entry for carbon monoxide.

4. Belt Entries - Longwalls Retreating

- A. Two-entry systems - Of the five retreating longwalls developed with two entries, three were using belt air at the face (two with monitoring systems; one without) and two were ventilating the belt entry with a separate split of intake air directed away from the face (one mine monitored this air for carbon monoxide and methane). The air in the belt entry of an advancing longwall at one mine was used at the face, however, the belt entry was not equipped with a monitoring system.
- B. Three-entry systems - All three mines retreating longwalls developed with three entries were coursing the air in the belt entry away from the face. None of these mines used monitoring systems.

- C. Four-entry systems - All four mines retreating longwalls developed with four entries were using the air in the belt haulage entry to ventilate the longwall face. Three of the four mines monitored this air for carbon monoxide.

5. Escapeways

A. Two-entry developments

- (1) Intake escapeways were located in the intake aircourse which also served as the haulageway for miners and supplies.
- (2) Alternate escapeways were located in the belt/return aircourse.

B. Three-entry developments

- (1) Intake escapeways were located in the intake aircourse which also served as the haulageway for miners and supplies.
- (2) Alternate escapeways were located in the belt haulage entry and ventilated by an intake split of air.

C. Four-entry developments

- (1) Intake escapeways were located in intake aircourse with the track or in a "smokefree"² intake.
- (2) Alternate escapeways were located in the return aircourse or the belt and trolley intake aircourse.

D. Longwalls

- (1) Intake escapeways were located in:
 - (a) Intake/haulageway
 - (b) "Smokefree" intake

²See Appendix A.

(2) Alternate escapeways were located in:

- (a) Belt haulageway
- (b) Track entry
- (c) Tailgate entry
- (d) Headgate through bleeders
- (e) Other headgate entry

6. Mobile Equipment

- A. Two-entry developments - In both mines developing with two-entry methods, diesel-powered equipment was used for various purposes on the panel. The remaining mine operators using two-entry systems reported diesel usage on the panels for transport of miners and materials. At one mine, diesel-powered equipment was used for coal haulage at the face.
- B. Three-entry developments - One of the mines utilizing three-entry development used diesel-powered equipment for transport of miners and materials. The other mine utilized electric track haulage for the same duties (battery-powered in panels).
- C. Four-entry developments - Of the five mines using four-entry development, two mines used battery-powered mantrips and haulage equipment, two mines used electric trolleys for personnel and materials transport, and one mine had recently adopted diesel-powered track-mounted mantrips.
- D. Longwall Retreat - The same methods described above for development work were also used during operation of the longwalls.

7. Electrical Installations - Ventilation

- A. Methods of Ventilating

- (1) Removal of one block or less from the top corner of the adjacent stopping.
 - (2) Removal of one block or less from the top center of the adjacent stopping.
 - (3) Removal of one block or less from the bottom of the adjacent stopping.
 - (4) Removal of several blocks from the adjacent stopping.
 - (5) Installation of one or more small diameter (2"-8") pipes through the adjacent stopping.
 - (6) Cracking open of the mandoor in the adjacent stopping.
- B. Many of the holes in the stoppings were obstructed with brattice, electrical cable, rock dust pipes, and/or mortar.
- C. In those mines using 20-foot yield pillars, electrical installations were largely located in the intake aircourse rather than in the cross-cut between the intake and the return.
8. Miscellaneous
- A. SCSR's - Most mines had storage plans. Many mines, particularly those developed with two-entries, stored SCSRs along the longwall face and in the tailgate entries.
- B. Panel lengths ranged from 500 to 7000 feet. Panel belts were installed as single flights on all longwall panels (i.e. no intermediate transfer points).
- C. Bleeders - Most mines had well maintained and travelable bleeder systems. Notable exceptions were those mines where access to bleeder

systems was intentionally prohibited, where spontaneous combustion in gob areas was a problem, or where advancing longwall techniques were employed.

FIRE HAZARDS/FIRE SUPPRESSION STUDY GROUP

Abstract

Fire hazards and fire suppression systems in 2-, 3-, and 4-entry longwall panels were investigated. These investigations concentrated on panel development and the longwall production phases in underground coal mines in both the eastern and western United States.

The fire hazards throughout these underground coal mines are multiplied if the uncontrolled accumulation of various combustible materials is allowed to occur. A certain amount of control can be exercised to restrict the accumulation of combustible materials through storage restrictions and safe storage locations. Because sufficient fuel (coal) and oxygen are always present to support fires and explosions, limiting sources of heat and energy which can cause an ignition is critical. From the findings of our underground field investigations, specific recommendations to reduce the fire hazards and to require fire-suppression systems at certain locations were developed.

The following is a listing of several specific elements evaluated by the Fire Hazards/Fire Suppression Study Group:

- Substantial and noncombustible stoppings and overcasts
- Fire-resistant sealants
- Low-density polyurethane foam system as a sealant
- High-density polyurethane foam system for roof stabilization
- Fire-resistant structures
- Fire-suppression systems on equipment and conveyor belts
- Storage of combustible liquids
- Type and location of fire-fighting equipment.

Specific recommendations in these areas have been made that can be immediately implemented in 2-entry, or 3- or more entry longwall development and long-wall panel mining.

GENERAL FINDINGS

1. All but two of the mines visited used 8-inch concrete block for stoppings. Three mines constructed drystacked stoppings with plaster on the intake side. However, most mines constructed stoppings with mortared joints. Metal stoppings were used exclusively at two mines, and three other mines used metal stoppings to a lesser degree. Wood stoppings were constructed between the belt entry and track entry at one mine. A polystyrene squeeze block was used as one course of some concrete block stoppings at one mine, and three mines used large (typically 4 ft. x 8 ft.) polyisocyanurate squeeze blocks, usually at the bottom center of concrete block stoppings where floor heave was a problem. All of these mines appeared to have substantial stoppings, but the stoppings with squeeze blocks and the metal stoppings may require additional protection to obtain a one-hour fire resistance rating.
2. Six of the fourteen mines used polyurethane as a perimeter sealant on ventilation control structures (usually metal stoppings or overcasts). Generally, applications of acceptable sealants to coal surfaces were not thick enough to provide fire protection.
3. In all but one of the mines visited, there was no underground storage of either high-density or low-density polyurethane foam systems. In that one mine, a large number of 5-gallon containers of polyurethane components was stored on a longwall panel where three electric heaters were used to keep these components warm.

4. Of the 2-entry mines visited, all but one had the emulsion pumps located in the headgate belt entry just outby the face. These pump locations were congested with hydraulic lines, electrical cables, and machinery. One 2-entry mine located its emulsion pumps off-panel in a well-maintained enclosure formed by an aluminum overcast, concrete floor, and a concrete stopping at the front and rear. This pump station was also protected by an automatically activated foam generator and other manual fire suppression equipment.

All 3-entry mines had the emulsion pumps located on-panel. Of the 4-entry mines, emulsion pump stations were located off-panel at two mines. At one mine the coal ribs were exposed, while at the other, a steel-plate ceiling had been installed and coated with a fire-resistant material. At two mines, the emulsion pumps were located on top of the stage loader in the headgate entry. One mine had mounted the pumps on a railcar for easy movement and pump motor replacement.

5. In all of the mines visited, power centers for longwall development and longwall panel retreat were located in crosscuts off the intake entries. A stopping was constructed on the return side of the power centers and the crosscut was open on the intake side. No power centers were located entirely in areas with walls having a minimum 1-hour fire resistance, and fire protection had not been applied to the coal ribs, although most of these areas appeared to be well rockdusted. None of the power centers observed in longwall development or on any longwall panel were provided with automatic fire-suppression systems; however, fire extinguishers and rock dust were provided.

None of the battery-charging stations on any longwall development or longwall panel were located entirely in areas with walls having a minimum 1-hour fire resistance. Typical battery-charging installations consisted of a charging unit in a crosscut with a stopping on the return side. Excluding rock dust, little or no other fire protection had been applied to any of the coal ribs in this area. Battery-charging stations were typically provided with openings in the tops of stoppings for ventilation.

6. All of the mines visited stored various quantities of oil and grease in by the panel mouth during longwall development and longwall panel retreating operations. In one mine, approximately 350 gallons of lubricating oil was stored along the track entry of the longwall panel. At another mine, a large oil storage area adjacent to a wood storage area was observed in the longwall panel intake entry. The fire extinguishers (two at each area) and the rock dust available (none at one area and seven bags at the other) were located such that they could possibly become involved in the fire or smoke from an area affected by fire. Also, the amount of fire-fighting equipment available at these oil storage areas or at any of the oil storage areas observed would only be effective on an incipient-stage fire.
7. The fire sources on diesel-powered equipment include diesel fuel, lubricating and hydraulic oil, grease, engines, brakes, and tires. Methane and coal dust ignition sources include hot exhaust and braking system components, electrical system arcing, engine backfires through the combus-

tion air intake system, and propagation of flame or discharge of heated particles through the engine exhaust system.

About half of the Part 36 diesel equipment observed was provided with on-board, manually-activated, multipurpose dry-chemical fire-suppression systems; the other half was provided with portable, multipurpose dry-chemical fire extinguishers. All of the Part 32 and the unapproved diesel equipment observed were provided with portable fire extinguishers.

No records of reportable diesel equipment fires in the mines visited were found; however, our research indicated there have been diesel equipment fires in both coal and noncoal mines which have had serious consequences, such as in the Beehive Coal Mine in Utah and Lakeshore Mine in Arizona. In both of these mine fires, the diesel engines were not shut down after the machines caught fire, resulting in out-of-control fires.

8. Conveyor belt used at all fourteen mines met the MSHA fire-resistance testing requirements. However, at one mine conveyor belting that met the British National Coal Board specifications was used because mine management desired the enhanced safety provided by the increased fire-resistance specifications.
9. In all of the mines visited, most of the fire-fighting equipment, such as fire extinguishers, rock dust, and fire hoses at electrical installations and storage areas for combustible materials were positioned so that they could become inaccessible due to fire or smoke. Fire hose locations at some mines were provided with bright, reflective signs along the main travel entry. Also, fire hose was stored in bright orange, metal boxes; and the valved water outlets were quickly located by red reflective markers.

ELECTRICAL STUDY GROUP

Abstract

Scope of the work included collecting information and preparing general findings and conclusions regarding the following:

1. Installation methods and practices for electrical distribution systems and equipment located underground. Special emphasis was placed on:
 - A. Location of equipment in relation to the intake escapeway, and the possibility of fire or explosion conditions caused by electrical equipment resulting in contamination of the intake air.
 - B. Housing of electrical equipment in fire-resistant locations.
 - C. Possible inundation of outby nonpermissible electrical equipment with methane due to bounces, bumps, outbursts, or massive roof falls in gob area.
2. Environmental monitoring systems, if used, that had the capability of monitoring electrical installations for fire and provide "early warning" for miners inby the affected area.
3. Mine communication systems, for reliability of operation during normal conditions and adverse conditions, such as during fires and other emergencies.
4. Future considerations, by the industry, for high voltage face equipment (e.g. 2300 and 4160 volts), automated longwall mining methods, and longer faces.

GENERAL FINDINGS

1. Electrical Equipment Locations and Practices

A. General Description - The mining methods and geological conditions varied substantially from mine-to-mine, but electrical installations and distribution underground were found to be very similar. Typically, a high-voltage system would be derived at a surface sub-station and distributed throughout the mine, at standard voltages ranging from 4160 VAC to 13.8 kVAC. These circuits supplied power to transformers, rectifiers, and high-voltage motors. The high-voltage cable was typically a 4/0 or 2/0 AWG, SHD, G-GC mine feeder cable, hung from a steel messenger wire attached to the roof of the entry. At transformer and rectifier stations, the voltage was stepped down to 110, 220, 480, 575, and 995 volts, as required, to provide power to the various electrical equipment.

Generally, electrical equipment was installed on intake air on the main, sub-main, and longwall panel entries. In almost every case, these entries were designated as the intake escapeway. Some mines in the eastern United States provided a separate "smokefree" intake entry on their mains and sub-mains, and in some cases, continued into longwall panel entries. These entries had no electrical equipment located in them. They were designated as the intake escapeway, and were isolated from other intake air entries containing electrical equipment.

The methods being practiced for ventilating major electrical installations were similar throughout the country. These methods are described in Sections B, C, and D, below.

- B. Transformers - Section transformers (power centers) were normally located in a crosscut, one or two crosscuts outby the face area, in the intake aircourse with a stopping on the return side. Generally, during development, these transformers were ventilated by a hole in the stopping with the air coursed into the belt entry or directly into a return. When longwall mining begins, the ventilation is usually changed so that the air passing over the transformer is taken to the face. The small size of yield pillars in some mines resulted in very short crosscuts. Therefore, the transformer was located adjacent to a stopping, but out in the entry.

Other transformer stations were generally located in intake air, usually in a crosscut with a block stopping on the return air side. Some cases were observed where a stopping was also provided on the intake air side of the crosscut, thus providing an enclosed area. Some of these stoppings were constructed of brattice cloth or partially constructed of concrete block. The ventilation provided for these transformers was accomplished by knocking a hole in the stopping or installing a pipe (2-inches to 8-inches in diameter) through the stopping or completely across an adjacent entry. Some transformers were vented into intake or neutral splits of air, others were not. The predominant practice observed was to locate the transformer in an

intake aircourse and knock a block out of the adjacent stopping provided on the return air side.

- C. Belt Drives - Belt drive locations investigated included main belt drives, longwall panel belt drives, and mid-point belt drives located in the longwall panel. These locations were normally ventilated with a regulated split of intake air.

Electrical equipment located in these areas included motors and starters for the belt drives, winches, pumps, and compressors. A fire-detection system (usually point-type heat sensor) and water-deluge system were provided for the belt drives. Many of the sensors were caked with dirt, rock dust, and coal dust. Generally, housekeeping on and around electrical equipment in these areas was minimal.

- D. Permanent Pumps, Compressors, and other Major Electrical Equipment - Permanent pump stations (for emulsion fluid for the longwall), water supply pumps and centralized compressor stations were provided at several mines. Installations varied from shop-like construction (concrete floors, concrete/steel walls and concrete/steel ceilings) to the equipment sitting in a crosscut with one stopping on the return air side and a hole in the stopping for ventilation.

- E. Face Equipment - Face equipment was generally being maintained in permissible condition. However, housekeeping could be improved.

When the emulsion pumps were located on the section, they were placed in the intake aircourse, immediately outby the face. Much leakage of emulsion fluid was observed. When this occurs, the water quickly evaporates, leaving only the oil to mix with loose coal, etc. and collect on and around the pumps.

2. Fire-Resistant Locations for Electrical Equipment

Construction methods for electrical installations were as follows:

- A. Major electrical installations located along the intake escapeway - A few pump stations were installed in well-constructed, fire-resistant structures vented to returns and provided with fire detection and suppression systems.

The majority of the permanent electrical installations (transformers, compressors, and pumps) were installed between two stoppings or with a single stopping on the return side and open on the intake side, and vented to the return. The roof, rib, and floor were rock dusted, but a structure meeting the fire-resistance requirements of ASTM E-119 was not provided.

- B. Other electrical installations located along the intake escapeway - Section transformers, auxiliary transformers, distribution boxes, and battery-charging stations located in the longwall panel entries, were installed as follows: the equipment was normally located in a crosscut off the intake entry, or out in the entry itself. This equipment was not located in an area meeting the fire-resistance requirements of ASTM E-119. However, most areas were well rock dusted. Fire detection and suppression were not provided except in the case of a few battery-charging stations. Battery-charging stations were the most poorly installed and maintained of all the electrical equipment.

3. Potential Methane Inundation of Nonpermissible Equipment

Several of the mines visited were considered by the Task Force as ultra-gassy. This condition, along with bumps, bounces, outbursts, and large

roof falls in the gob area, could cause explosive mixtures of methane to be backed up the intake entries beyond nonpermissible electric equipment (section transformer). Section transformers were located within 150 feet to 500 feet of the face, which has been normal mining practice and, therefore, well within the area which could be inundated with methane. One mine provided a monitoring system to safeguard against this condition. However, it was used only during panel development work. The system monitored for methane and alarmed at 0.8 percent concentration and deenergized the transformer at the mouth of the section (all section power) when methane concentrations of one percent were detected at the mouth of the section and/or immediately outby the conveyor tailpiece.

4. Wiring Methods, Circuit Protection, and Electrical Hazards

Some electrical systems were found to be overextended, creating a condition where the current flow caused by a short circuit would be less than that required to operate the protective devices. This condition could easily result in a fire should a short circuit occur in the system. Especially vulnerable were the overextended high voltage branch circuits to the longwall section transformers.

Other overextended circuits observed in some mines were those circuits serving dewatering pumps in remote areas, and several of the low-voltage circuits on the longwall panels which supplied power to production support equipment, such as welders, rockdusters, hoists, etc.

Circuit breakers were observed with the instantaneous trip units adjusted to the maximum setting. These settings were, in most cases, much higher than advisable for protecting the associated cables against short circuits. Two of the mines visited conducted a program of calibrating circuit breakers

on a regular basis and attaching a tabulation of the calibrated settings to each breaker.

It is good engineering practice to protect the trailing cables against physical damage. A few LW system trailing cables were observed being routed through holes in concrete block stoppings without guarding (being) provided. In some instances, the high voltage cables in the panel entries were "cut and spliced" as the entries were developed and as the longwall was retreated.

5. Environmental Monitoring System (EMS), where used, that monitored electrical installations or could be used to monitor electrical installations. The environmental monitoring systems investigated were generally used to monitor for carbon monoxide on belt entries on intake and, in some cases, for methane at face areas and in returns. One mine had the fire-detection system at belt drives interfaced with the EMS system. Another mine had the fire-detection system interfaced with the mine phone system, which would output a pre-recorded voice message throughout the mine communication system when the fire detection/fire suppression system at a specific panel belt drive was activated. All EMS designs had the capability of monitoring belt entries and also major electrical installations. However, not all the systems were being utilized to their full potential.

6. Mine Communication System

Communication cables in some cases were routed with power cables, control cables, hydraulic lines, and water hoses. Generally, the communication cable was hung loosely from the mine roof, usually on the main haulage

road and was vulnerable to physical damage by passing vehicles, weathering of mine roof, fires, roof falls, explosions, etc.

One mine operator, realizing the vulnerability of the phone system, had installed a separate phone at the longwall tailpiece, with the phone cable routed up the tailgate entry and parallel to the mine communication system. This method provides some redundancy on the longwall panel. All other mine operators expressed concern for the vulnerability of their communication system, particularly during an emergency, but had not developed practical solutions.

7. Future Considerations for Longwall Electrical Systems

Generally, personnel at the mines visited are considering increased face lengths and higher productivity requirements which would lead to the need for high voltage longwall electrical systems. Presently, longwall faces require approximately 1500 horsepower. Increased face lengths and productivity would obviously require more horsepower to do the work. The trend in the industry is toward supplying high voltage electrical systems (e.g. 2300 or 4160) to the face to meet the increased demand. High voltage equipment is presently in use at a gassy metal and non-metal mine and has been requested for use in at least two coal mines.

Automation of longwall mining methods, especially the operation of the shields, was not observed at any of the mines visited. However, several mines were contemplating automation (programmable controllers), and would seriously consider it once a proven automated longwall method was developed.

8. Electrical Safety Devices and Practices on Longwall Faces

Face communications on longwalls varied from two-way voice communication to push-button/tone types. Face conveyor lockout procedures and pre-start alarms were provided on most longwalls, although some longwalls had none. On one longwall, a pull-cord emergency stop device was observed that extended the entire length of the face conveyor.

FIRE DETECTION STUDY GROUP

Abstract

The use of two entries on longwall panel development limits the number of escape routes available to miners in an emergency. In the event of a fire outby the working section or a build-up of methane, EARLY WARNING of the hazardous condition is paramount to the safety of the miner.

During this investigation, fourteen mines were visited. Of these fourteen, eight mines employed environmental monitoring systems, ranging in complexity from simple to highly sophisticated, for fire detection purposes. Each system used sensors that detected methane and/or carbon monoxide and supplied this information to master stations. Of the eight master stations, six were surface computer installations and two were remote underground stations. All but one mine visited used the traditional belt fire-detection systems employing point heat detection techniques and remote annunciators.

The Task Force suggests the use of an environmental monitoring system on all longwall panels and longwall development sections. An environmental monitoring system is considered critical for safe operation of the panel when certain situations exist. These situations are:

1. When air used to ventilate the belt haulage entry is used to ventilate active working places,
2. The belt entry is also a return aircourse,
3. The intake and alternate escapeways are on the same continuous split of air,

The environmental monitoring system must be manufactured, installed, and maintained in a manner that ensures total system reliability.

GENERAL FINDINGS

1. Sensors

CO sensors were installed in appropriate locations, in most cases, for early detection of a fire in the belt entry. The established ambient level of CO in the mines was noted to vary extensively (0 ppm to 35 ppm). A diffusion-type sensor was used for CO monitoring in all but two of the mines visited. Smoke detectors were not in use in any mine visited and point-type heat sensors were not included as part of any environmental monitoring system observed.

The situation existed in one mine where sensors derived their power from the longwall power center and no battery back-up power was provided.

2. Alarms

Alarm was observed to be automatic in the case of a detected event in most cases. This alarm was always both visual and audible and was accompanied by oral communication in all but two systems. In one case, the alarm was not detectable when the panel was in production because of excessive background noise. Alarm levels were normally set as follows:

10 ppm CO above ambient - alarm @ surface

15 ppm CO above ambient - alarm @ section and surface

0.8% CH₄ - alarms @ section

1.0% CH₄ - alarms @ section - power deenergized

3. System

The management of mines with a surface installation assigned a person to be responsible for action in the event of a surface alarm. In one mine, different alarms were sounded to denote different events.

4. Mine Summary

Fourteen mines visited; eight had environmental monitoring systems (EMS).

Two Entry - EMS

2 - on development

1 - on retreat

1 - not operating due to the mine being idle

CO monitoring in longwall belt entry

CH₄ monitoring in longwall belt entry

Three Entry - EMS

None of the three-entry mines visited had an EMS.

Four Entry - EMS

4 - minewide (environmental only)

CO monitoring on all production belts in mine

TECHNICAL RECOMMENDATIONS AND DISCUSSIONS

Because a comprehensive review of safety and health considerations for longwall mining in the United States had not previously been conducted, the Task Force recognized soon after its organization that it could have a significant impact on the safety and health aspects of longwall mining. For this reason, the Task Force deliberated with sufficient independence to ensure that its final recommendations would not simply restate existing policy and/or regulations.

To accumulate information regarding actual underground conditions and longwall mining practices, the Task Force visited seven mines utilizing 2-entry systems, two mines using 3-entry systems, and five mines using a 4-entry system. All but two of these mines were operated at depths in excess of 1000 feet.

The most difficult problem which confronted the Task Force was determining the degree of applicability of its recommendations to specific longwall mining situations. The Task Force understands that not all of its recommendations will apply to all situations and conditions. After much discussion, a format was selected which classifies all recommendations in one of three categories. The classifications adopted by the Task Force are:

AAA - Safeguard addresses a condition or practice which presents a safety concern such that immediate action is warranted.

BB - Safeguard addresses a potentially severe safety concern which should be considered on a case-by-case basis.

C - This recommendation addresses potential safeguards where additional study and/or research may result in improved safety.

The first seven of the Task Force's recommendations fall within the first category. The Task Force believes that all seven recommendations, or equivalent measures, are needed to insure an acceptable level of protection.

1. FOR ALL LONGWALL MINING OPERATIONS, A SAFE TRAVELWAY, UNDER SUPPORTED ROOF THROUGH TAILGATE ENTRIES OR BLEEDERS TO A MINE EXIT, BE PROVIDED OFF THE FACE ON THE TAILGATE SIDE FOR EMERGENCY PURPOSES AT ALL TIMES WHILE PERSONNEL ARE PRESENT. TO VERIFY THAT TRAVELABILITY IS MAINTAINED, A WEEKLY EXAMINATION OF THIS TRAVELWAY IS RECOMMENDED. - AAA

The exit routes off all longwall panels are limited to the headgate entries, the tailgate entries, and the bleeders inby the face on the tailgate side. A travelway is always maintained on the headgate side of the panel as the mining process itself depends upon the transportation of personnel, supplies, and coal to and from the face area through these entries. Therefore, at least one entry on the headgate side of the longwall face should be free of obstruction and available for exit in emergency situations. In the event of a life-threatening occurrence in the headgate entries, such as a fire in the intake aircourse or an outburst of the face which impedes passage and impairs ventilation, egress from the longwall panel for persons inby the affected area should

not require travel across the longwall face. A ground failure or any other blockage in the tailgate entry requires that additional ventilating pressures be supplied to overcome the increased airway resistance caused by the restriction, and to restore the longwall air volume to its prescribed value. Any restriction of the tailgate airway so severe as to prohibit its use as a travelable route may present a serious impairment to proper ventilation of the longwall.

In two-entry longwall systems, where the headgate entry of the previous panel caves with mining, a ground failure in the tailgate entry poses an immediate obstruction to egress from the panel, unless a route is available adjacent to the gob through the bleeders, and an impairment to ventilation of the longwall face.

In multiple-entry systems, a ground failure in the immediately adjacent tailgate entry may not initially impede passage, as a route skirting the obstruction through other gate entries or bleeders may be established. Similarly, ventilation may not be impaired to the same degree as in a two-entry system since an aircourse through adjoining tailgate entries may be established. However, when mining progresses to a point where the face abuts the failed area, egress off the panel on the tailgate side will be impeded and ventilation of the longwall face will be impaired.

2. BLEEDER ENTRIES BE PROTECTED BY ADEQUATE SUPPORT PILLARS AND/OR BARRIER PILLARS AND BE MAINTAINED TO ENSURE ADEQUATE VENTILATION AND METHANE CONTROL IN GOB AREAS AND ASSOCIATED ENTRIES. - AAA

Bleeder systems are designed and developed to move methane-air mixtures from the gob, away from the active workings, and to the mine return aircourses. Failure of a bleeder system could result in dangerously high accumulations of methane in active workings. Therefore, it is imperative when bleeder systems are employed, that the system be well designed and maintained open with supplemental supports as needed. Some mines develop two or three entries as set-up rooms, and then employ those set-up rooms as bleeder entries. Significant problems are often encountered with such arrangements because the entries often cave and impair the effectiveness of the bleeders. The caving problem in bleeder entries appears to be minimized when bleeder entries are developed separate from set-up rooms. A single large-support pillar (barrier pillar) or multiple pillars of smaller size should be utilized to protect bleeder entries from damage due to overriding stresses around the perimeter of gob areas.

3. ONE-HOUR, SELF-CONTAINED SELF-RESCUERS (SCSRs) BE CARRIED BY EACH PERSON ON A LONGWALL PANEL OR THAT SCSRs BE STORED NEAR THE STAGE LOADER AND ON OR NEAR THE FACE ON THE TAILGATE SIDE OF ALL LONGWALL PANELS. WHEN THE TIME REQUIRED TO TRAVEL ACROSS A LONGWALL FACE BECOMES EXCESSIVE, SCSRs BE STORED AT LOCATIONS ALONG THE LONGWALL FACE. - AAA

If SCSRs are not carried by each person at all times or if SCSRs are not available near the tailgate side of the longwall, it is possible that a person would be unable to reach a SCSR if an emergency occurred while that person was on the longwall face. Travel along the longwall face is often difficult and slow and face lengths may soon exceed 1000 feet. This long travel time could cause a person to be overcome by a toxic atmosphere before that person could reach a SCSR stored near the stage loader. Additionally, the clearance between the conveyor system and the supports along the longwall face is limited and could be blocked preventing escape to the headgate side of the longwall face, thereby leaving the tailgate side of the longwall as the only escape route.

4. AN ENVIRONMENTAL MONITORING SYSTEM BE INSTALLED IN THE INTAKE ESCAPEWAY OF ALL LONGWALL DEVELOPMENTS AND LONGWALL PANELS WHEN BOTH DESIGNATED ESCAPEWAYS ARE VENTILATED BY ONE CONTINUOUS SPLIT OF AIR. THE SENSING DEVICES IN THIS MONITORING SYSTEM BE LOW-LEVEL CARBON MONOXIDE MONITORS OR SENSORS FOR ANOTHER PRODUCT-OF-COMBUSTION THAT ARE NO LESS EFFECTIVE. - AAA

A fire outby the longwall development or panel would contaminate both escapeways with carbon monoxide and smoke, hampering escape. Early warning of the fire condition is critical to the safety of the workers. The monitoring should be done at all times when personnel are on that section. Sensors should be located at the mouth of the panel, immediately outby the last open crosscut and at designated locations between these two points. The sensors should be installed in the main airstream in the entry, in an accessible location for safe calibration and inspection, and in a workmanlike manner. They should not rely solely on the section power center as their power source. A battery back-up or other alternate, off-panel power source should be provided.

To provide an adequate warning to miners in the event of a fire, consideration must be given to the placement and location of the sensors. Research has been conducted to determine proper spacing between different sensors. This research indicates that mine ventilation methods and mine geometry should be considered when determining sensor location.

The monitoring system should be intrinsically safe underground or have the ability to be deenergized under loss-of-ventilation conditions.

A system "warning" level of 10 parts per million (ppm) CO above the pre-established ambient CO level of the mine should be established. An "alarm" level of 15 ppm above this ambient should also be used. The ambient CO level

of the underground environment should be defined on a mine-to-mine basis and, in mines where diesel equipment is used, the ambient should be established without the diesels in operation.

When any event is detected at the "warning" level, an alarm should be sounded at a surface installation where a person(s) responsible for action is always on duty when personnel are underground. They should have two-way communication capability with the affected areas of the mine. The sensor(s) in "alarm" condition should be identifiable by location and type of sensor. Additionally, when any sensor detects gas in excess of the preset "alarm" level, an alarm should be given on the affected section at a location where it can readily be seen and heard.

Under either "warning" or "alarm" conditions, instructions should be provided to personnel underground and to the person manning the surface installation as to the appropriate action. Miner training to recognize and respond to these "warning" or "alarm" conditions is very important and needs to be conducted on a regular basis.

In the event of a damaged component or interconnecting cable in the monitoring system, automatic notification of the malfunction should be given at the surface and prompt corrective action should be taken. In the case of lost communication between the surface installation and the remote underground data collection stations, the underground system should still provide the appropriate alarms to the section during emergency conditions.

Resetting the section alarm should be accomplished at a location that would ensure investigation of the cause of the alarm. To verify continued reliable operation of the systems, all sensors should be calibrated once every 30 days using a known concentration of gas and visually inspected once each working shift.

5. AN ENVIRONMENTAL MONITORING SYSTEM BE INSTALLED IN THE BELT HAULAGE ENTRY WHENEVER BELT AIR IS USED TO VENTILATE ACTIVE WORKING PLACES, OR THE BELT ENTRY IS USED AS A RETURN AIR-COURSE. THIS SYSTEM SHOULD UTILIZE LOW-LEVEL CARBON MONOXIDE MONITORS OR SENSORS FOR ANOTHER PRODUCT-OF-COMBUSTION THAT ARE NO LESS EFFECTIVE IN BOTH CASES. ADDITIONALLY, WHEN THE BELT HAULAGE ENTRY IS USED AS A RETURN AIRCOURSE, METHANE MONITORS BE USED. - AAA

The belt haulage entry contains numerous potential fire sources as well as combustible material. When the air ventilating this entry is directed to the active working place, contaminants, such as smoke particulate and carbon monoxide, travel to the face in the event of a belt haulage entry fire. Monitoring should be done any time personnel are on the section. These sensors should be located immediately inby belt drives, at the most inby belt tailpiece and at designated intervals between these two points. Otherwise, sensor locations and system operation should be the same as that described in recommendation No. 4.

Methane build-up is possible in explosive mixtures in the return aircourse. As stated above, there are numerous ignition sources in the belt haulage entry. When methane gas is detected above a pre-established level in this area, all power should be disconnected to the electrical equipment in the affected area to safeguard against explosions of methane-air mixtures. Monitoring should be required whenever the belt haulage entry is also a return aircourse. The sensor stations (consisting of a product-of-combustion sensor and a methane sensor) should be located just inby the point where the panel return joins the

main return, just outby the most inby belt tailpiece, and at designated locations between these two points. At 0.8% methane-in-air, an alarm should be sounded and, at 1.0% methane-in-air, all the power to the panel or development should be disconnected. The alarm, sounded for excessive methane content of the air, should be separate and distinct from that sounded for high CO. Otherwise, system operation and sensor placement should be as stated in recommendation No.

4.

6. ALL DIESEL-POWERED EQUIPMENT, OPERATED ON ANY LONGWALL DEVELOPMENT OR LONGWALL PANEL WHERE BOTH THE INTAKE AND ALTERNATE ESCAPEWAYS ARE VENTILATED WITH THE SAME CONTINUOUS SPLIT OF AIR, BE APPROVED UNDER THE PROVISIONS OF 30 CFR, PART 36 AND BE PROVIDED WITH A FIRE-SUPPRESSION SYSTEM. -
AAA

Diesel-powered equipment has associated with it an additional safety hazard not present with electrically-powered equipment. The proximity of combustible materials (diesel fuel and hydraulic fluid) with a potential ignition source (the hot manifold) may make the operation of diesels which have not been designed to address these problems too hazardous for use in areas of a mine with limited escape routes. Diesel-powered equipment approved under the provisions of 30 CFR, Part 36 has been designed to reduce the likelihood of a machine fire, and when a fire-suppression system is used in conjunction with these other design features, the potential for an uncontrolled fire on a piece of diesel-powered equipment is greatly reduced.

7. OVERCASTS AND STOPPINGS ON ALL LONGWALL DEVELOPMENT AND LONGWALL PANELS BE STRUCTURALLY EQUIVALENT TO AN 8-INCH HOLLOW-CORE CONCRETE BLOCK STOPPING WITH MORTARED JOINTS, AS PER ASTM E-72 OR EQUIVALENT, AND PROVIDE A MINIMUM FIRE-RESISTANCE OF 1 HOUR, AS PER ASTM E-119 OR EQUIVALENT. - AAA

Controllable ventilation is of utmost importance during all phases of mining, but especially during mine emergencies. The 8-inch hollow-core concrete block is the structural unit most typically used for ventilation control in underground coal mines. To establish minimum structural and fire-resistance requirements for permanent stopping and overcast construction, the 8-inch block with mortared joints is used.

The 8-inch block stopping displays the following performance characteristics:

- (1) Minimum transverse loading of 39 lb/ft^2 on a vertical specimen as determined by Section 10, "Transverse Load - Specimen Vertical," of ASTM E-72 method of test, "Conducting Strength Tests of Panels for Building Construction." Section 10 of ASTM E-72 is appropriate for stoppings and overcast walls. However, Section 11, "Transverse Load - Specimen Horizontal" of ASTM E-72 is appropriate for overcast tops with a minimum transverse loading of 39 lb./ft^2 .

The minimum transverse loading is an indication of the amount of static pressure that the overcast wall or top can withstand before failing. It has been used as a guideline to assess potential permanent stopping systems for a number of years with successful results.

- (2) A minimum 1-hour fire-resistance rating as per ASTM E-119 method of test, "Fire Tests of Building Constructions and Materials."

This rating is considered to be a reasonable time frame for miners to safely exit a fire area via an escapeway during an emergency. Wall partitions in buildings are assigned ratings according to the wall's fire resistance; ventilation control structures in mines are considered on an equal safety basis.

The fire-resistance rating is essentially the time that the wall can be expected to resist the passage of heat, flame, or hot gases, any of which could ignite combustible material on the opposite side of the wall, when the wall is subjected to heat from a carefully controlled energy source, such as a furnace.

All stopping components, including block, metal, wood, manddoors, foam-type squeeze blocks, etc., should combine to meet the performance characteristics previously mentioned. For example, foam-type squeeze blocks have a very short, inadequate fire resistance if left untreated and would, therefore, require a fire-resistant coating.

The second grouping of recommendations established by the Task Force presents safeguards which address potentially severe hazards and can be adopted to augment existing practices to enhance safety. Each of these recommendations should be considered on a case-by-case basis when developing and reviewing a mining plan. Twenty-five of the Task Force's recommendations fall within this category.

8. FOR EACH GROUP OF SUCCESSIVE LONGWALL PANELS, UNLESS MINING CONDITIONS DICTATE OTHERWISE, SYSTEMATIC SUPPLEMENTAL SUPPORT BE INSTALLED THROUGHOUT THE TAILGATE ENTRY OF THE FIRST LONGWALL PANEL PRIOR TO MINING THAT PANEL. - BB

Tailgate entries are known areas of extremely high stress associated with the retreat of longwall panels. In order to assure that tailgate entries remain open ahead of the longwall face, systematic supplemental support is generally installed throughout. Maximum ground stability can be attained if supports are installed before stresses induced by mining affect these areas. While supplemental support could be installed in advance of the abutment stresses developed as mining progresses, workers installing these supports could be unnecessarily exposed to unstable ground conditions and/or high concentrations of respirable dust if that entry serves as a return aircourse. Since the entire tailgate will ultimately be supported in its entirety, installing these supports prior to mining the panel can significantly reduce exposure to these conditions and enhance ground stability.

9. UNLESS MINING CONDITIONS DICTATE OTHERWISE, SYSTEMATIC SUPPLEMENTAL SUPPORT FOR TAILGATE ENTRIES OF SUBSEQUENT LONGWALL PANELS BE INSTALLED IN ADVANCE OF THE FRONTAL ABUTMENT STRESSES OF THE ADJACENT PANEL BEING MINED. - BB

As longwall panels are mined, it is common for abutment stresses to migrate ahead of the longwall face on both the headgate and tailgate sides. The outer headgate entry of the panel being mined will serve as the tailgate entry of the next panel. Systematic supplemental supports are generally installed in this entry as mining advances in order to maintain stability. By installing these supports in advance of the abutment zone, the exposure of miners to potential strata failure resulting from high stress levels can be limited, and the effectiveness of the ground support system can be maximized. In the absence of evidence to the contrary, it is recommended that these supports be maintained at least 200 feet ahead of the longwall face.

10. PROCEDURES BE FORMULATED BY THE OPERATOR THAT ADDRESS THE ACTIONS TO BE TAKEN BY THE COMPANY SHOULD THE TAILGATE TRAVEL-WAY BE CLOSED DUE TO AN UNPLANNED GROUND FAILURE. - BB

Experience has shown that even in well-supported entries, unplanned ground failures may occur. It can, therefore, be to the benefit of the operator to anticipate what actions might be taken if a longwall tailgate is unexpectedly closed and safe egress off that panel on the tailgate side is blocked. Several alternatives, which could apply, are: mining a new tailgate entry, rehabilitation of the failed area to a travelable condition, discontinue mining of that panel, etc. Consideration should be given to the equipment and materials needed to carry out the various alternatives prior to mining each panel.

11. THE DESIGNATED AREAS FOR RESPIRABLE DUST SAMPLING INCLUDE LOCATIONS IN THE BELT/RETURN AIRCOURSE OF ALL TWO-ENTRY LONG-WALL PANELS DURING DEVELOPMENT. ONCE DESIGNATED, THESE AREAS BE SAMPLED FOR THE ENTIRE TIME THE PANEL IS BEING ADVANCED. - BB

Miners working in the belt haulage entry of a two-entry development may be exposed to high levels of respirable dust if the belt is in the return air-course. Under the area sampling program, personal sampling of miners working in areas outby the section loading point is not done and, therefore, respirable dust concentrations measured at designated areas in the belt entry of a two-entry development are the only indication of the respirable dust levels to which miners working in the belt haulage entry may be exposed. For this reason, once a location in the belt haulage entry of a two-entry system has been made a "designated area," it should remain so for the entire time the panel is being advanced and not be removed.

12. THE ASSIGNMENT OF THE DESIGNATED OCCUPATION BE BASED ON RESPIRABLE DUST SAMPLING OF EACH FACE OCCUPATION ON EACH TWO-ENTRY DEVELOPMENT. - BB

On a two-entry development, the continuous miner and the roof bolter must both operate on the same split of air. Therefore, one of these machines will always be on the return-air-side of the other machine, and the operator will be exposed to the dust generated by that machine. Additionally, shuttle car operators may be exposed to dust generated by both the continuous miner and roof bolter. Because the belt is located in the return aircourse on a two-entry development, the shuttle car operators may be exposed to high concentrations of respirable dust when traveling in the return airway to the belt tailpiece if the discharge end of the face ventilating device is inby the belt tailpiece. Therefore, on a two-entry development, the continuous miner operator should not automatically be made the designated occupation. The designated occupation should be determined after all section face workers have been sampled to determine their individual respirable dust exposures.

13. FOR ALL PERSONNEL ON THE SECTION, TRANSPORTATION BE MAINTAINED NEAR THE SECTION FOR ALL LONGWALL SYSTEMS AND LONGWALL DEVELOPMENT PANELS. - BB.

A means of rapid escape is highly desirable during an emergency. Fires may expand rapidly blocking escape for all persons inby. With current industry trends toward longer panels, travel times by foot off the panel may conceivably be in excess of one hour, particularly in low coal. The time rating of existing self-contained self-rescuers may, therefore, be less than the time required for escape by foot. Escape via motorized transport may be faster than travel by foot in these instances. The provision for transportation near the section for all miners on the section would provide a means of rapid escape from longwall and longwall development panels.

14. OFF-PANEL STORAGE AREAS FOR COMBUSTIBLE LIQUIDS AND ALL MAJOR ELECTRICAL INSTALLATIONS³ LOCATED IN THE INTAKE ESCAPEWAYS BE PROVIDED WITH:

- (A) A POSITIVE MEANS OF VENTILATION DESIGNED TO CARRY PRODUCTS OF COMBUSTION DIRECTLY INTO A RETURN AIR COURSE,
- (B) A LOCATION HAVING A MINIMUM OF ONE-HOUR FIRE RESISTANCE, AND
- (C) AN AUTOMATIC FIRE-SUPPRESSION SYSTEM THAT IS MONITORED FOR OPERATION. - BB

Keeping intake escapeways free of contamination during any mine emergency, especially mine fire, is vital. Large storage areas for combustible liquids and all major electrical installations present serious fire hazards. If these storage areas or electrical installations are located in the intake escapeway, certain precautions must be undertaken to ensure that all inby personnel could escape in the event of a fire.

A positive means of ventilation, designed to carry products of combustion directly to a return aircourse, would allow inby personnel time to escape in intake air that is not contaminated by smoke, toxic gas, or other harmful products of combustion. Placing these storage areas and electrical installations in locations with walls having a minimum of 1-hour fire-resistance rating would prevent the passage of heat, flame, or hot gases. This would effectively allow inby personnel time for safe evacuation through areas that are unaffected by the fire.

³See Appendix B.

An automatic fire-suppression system prevents any incipient fire from developing. To alert mine personnel of a fire in this area, the automatic fire-suppression system should be monitored for operation.

15. BATTERY-CHARGING STATIONS ON LONGWALL DEVELOPMENT AND PANELS WHERE BOTH ESCAPEWAYS ARE VENTILATED WITH THE SAME CONTINUOUS SPLIT OF AIR BE:

- (A) LOCATED IN A FIRE-RESISTANT AREA,
- (B) EQUIPPED WITH A FIRE-SUPPRESSION SYSTEM, AND
- (C) WHERE A RETURN AIRCOURSE IS AVAILABLE, VENTED DIRECTLY INTO THE RETURN OR, WHEN A RETURN AIRCOURSE IS NOT AVAILABLE, MONITORED BY A SUITABLE FIRE-DETECTION SYSTEM. - BB

There are certain fire and explosion hazards associated with battery-charging stations. During emergency situations, it is very important to have escapeways which allow all inby personnel time for safe evacuation. Also, there are occasions when the intake and alternate escapeways are ventilated with the same continuous split of air. If this is the case, certain precautions must be undertaken at battery-charging stations to prohibit contamination of the aircourse and allow inby personnel time for safe evacuation.

Battery-charging stations should be located in a fire-resistant area. A typical fire-resistant area may include a substantial and noncombustible stop-ping and all coal surfaces coated with, at least, minimum thicknesses of acceptable sealants. Also, these areas should be equipped with a fire-suppression system that is either manually or automatically activated. Easy access to this fire-fighting equipment (suitable fire extinguishers and rock dust as a minimum) is necessary. Where a return aircourse is available, the battery-charging station should have a positive means of ventilation directly into the return. Where a return aircourse is not available, a suitable fire-detection system should be effectively located at the battery-charging station.

16. TROLLEY CIRCUITS LOCATED ON THE LONGWALL PANEL INTAKE ESCAPE-WAY BE ENERGIZED FOR SET-UP AND RECOVERY OF THE LONGWALL MINING SYSTEM ONLY. - BB

Trolley wires and trolley feeder wires located in the intake escapeway present a serious fire hazard. These conductors are uninsulated and conduct enough energy to create a fire. In the event of a roof fall, where the trolley wire comes in contact with a metal structure (roof supports, straps, arches, track fishplates, etc.), a high-resistance current path can be established. This high-resistance path can also be caused by a damaged insulator or other conditions created by a haulage accident. When any of these conditions occur, the circuit protective devices cannot respond to the reduced current flowing in this new circuit. The temperature of the metal structures will increase until the surrounding combustible materials are ignited. The resultant mine fire in the intake escapeway will cause products of combustion to go to the working section and will block this primary escape route.

In order to set up and recover a longwall system, a trolley-powered locomotive may be required to move the equipment. The trolley can be installed for the length and time necessary to set up the longwall and then be removed to the recovery point of the longwall system. The existing trolley wire remaining in the longwall panel should remain deenergized until longwall equipment recovery takes place. Extreme care should be exercised when transporting equipment via the trolley system.

17. WHEN THE TAILGATE ENTRY IS USED AS A RETURN AIRCOURSE, THE TAILGATE ENTRY, AT A POINT JUST INBY THE INTERSECTION OF THIS AIRCOURSE AND THE MAIN AIRCOURSE, BE MONITORED FOR CARBON MONOXIDE AND METHANE CONTENT. - BB

The tailgate entry and the longwall face on the tailgate side contain numerous combustible materials (loose coal, coal dust, wood, cables, etc.) and potential ignition sources (pumps, motors, lights, etc.). Recommendation No. 1 of this report is to keep the tailgate entry open to allow for miners to travel this route in the event of an emergency. This travelway can become contaminated because of a fire or an accumulation of methane. Spontaneous combustion in an adjacent gob, an electrical fire on the longwall tailgate equipment (tailgate motor, plow motor, lighting, etc.), dewatering pumps in the tailgate entry, possible latent combustion from maintenance (cutting and welding) on the tail equipment, and accumulations of methane from the adjacent gob and working face are situations of which miners should be made aware. The placement of a carbon monoxide and methane sensor at a point just inby the intersection of the tailgate entry and main return aircourse will allow continuous monitoring and provide an early warning to inby areas in the event of an emergency.

18. ENVIRONMENTAL MONITORING SYSTEMS BE PERIODICALLY EVALUATED
FOR PERFORMANCE. - BB

The performance of the environmental monitoring system is critical for the early warning of possible mine emergency conditions. The total system, including sensors, alarms, and processing equipment, should be tested periodically to ensure continued system reliability. Procedures to accomplish this verification have been developed by the manufacturers. These procedures should be used by the mine operators to check total system performance at least every 30 days and random testing by MSHA enforcement during inspections.

19. SEALANTS APPLIED TO VENTILATION CONTROL STRUCTURES HAVE A FLAME-SPREAD INDEX OF 25 OR LESS, AS PER ASTM E-162 OR EQUIVALENT. SEALANTS APPLIED TO COAL SURFACES TO MEET THE FIREPROOFING REQUIREMENTS OF 30 CFR 75.1105 BE APPLIED IN, OR EXCEED, THE MINIMUM THICKNESSES FOR THAT SEALANT. - BB

There are currently no mandatory safety standards governing sealants. However, it is very important that sealants do not contribute to the propagation of flame or flame penetration. Certain ventilation control structures may require the application of an acceptable sealant for this purpose and these sealants should have a flame-spread index of 25 or less. For applications of acceptable sealants on continuous rib and roof coal surfaces, the noncombustible requirements, as per ASTM E-136, should be met. In addition, these sealants should be tested for flame penetration as described in the U.S. Bureau of Mines' Report of Investigations 6837. Special flame penetration tests were primarily conducted on these sealants to determine the minimum thicknesses necessary to prevent ignition of coal at the interface of the sealant and coal (300°F) in the event of a fire on the exposed side of the sealant.

20. HYDRAULIC FLUID (EMULSION) PUMP STATIONS BE LOCATED IN STRUCTURES WITH WALLS HAVING A MINIMUM 1-HOUR FIRE RESISTANCE, AS DETERMINED BY ASTM E-119 OR EQUIVALENT. NO SUCH PUMP STATIONS BE LOCATED ON A 2-ENTRY LONGWALL PANEL. - BB

Hydraulic fluid (emulsion) pumps located in headgate entries are at attended locations. However, these pumps are a fire source in that grease, oil, coal dust, and other combustibles accumulate around the pumps which have high surface temperatures while in operation. When the pumps are located adjacent to the tailpiece, the travelways between the pumps and the conveyor are quite restricted. The restricted travelways and the limited clearances around the pumps are congested with hydraulic piping and hoses between and alongside the pumps. The narrow and uneven travelway surfaces present tripping hazards by their very nature.

Relocation of the pumps to an off-panel location, placed in a fire-resistant structure and in an area where the pumps can be properly supervised and maintained, would eliminate on-panel fire and tripping hazards. Because of the limited escapeway options available in a 2-entry system, the location of the pumps at an off-panel pump station would reduce the associated fire hazards.

21. LUBRICATING OIL, GREASE, AND COMBUSTIBLE LIQUIDS NOT EXCEED A 1-DAY SUPPLY ON ANY LONGWALL DEVELOPMENT OR LONG-WALL PANEL. DIESEL FUEL NOT BE STORED ON 2-ENTRY PANELS. - BB

Lubricating oil, grease, and other combustible liquids can present a severe fire hazard, especially due to the close proximity to other ignition or fire sources on longwall development or retreat panels. The minimum amounts of these combustibles necessary for operation would, therefore, present the lowest fire hazard possible. Diesel fuels are combustible liquids that may be used in large quantities. Diesel fuels burn very inefficiently in fires, generating dense smoke and intense heat. As little as one gallon of diesel fuel, burning unconfined, can create enough smoke to make visibility and escape very difficult. Because of the limited escapeway options available in a 2-entry system, the fire hazard presented by the storage of diesel fuels would be greatly reduced if diesel fuels were not stored on the panel during development or panel mining.

22. NO UNDERGROUND STORAGE OF POLYURETHANE BE PERMITTED. THIS APPLIES TO BOTH HIGH-DENSITY POLYURETHANE USED FOR ROOF STABILIZATION AND TO LOW-DENSITY POLYURETHANE USED AS A SEALANT. - BB

Polyurethane foam systems are used for roof stabilization and, in some cases, for ventilation improvement, such as perimeter sealing of stoppings and overcasts. These systems consist of isocyanates and polyol liquids. Also, certain blowing agents are added for application on ventilation controls. The isocyanate compound is very toxic, with a TLV of 20 parts per billion. Both polyurethane foam systems are combustibile and pose a serious risk in the event of a fire. Polyurethane will burn very hot and will produce toxic chemicals upon decomposition. For example, isocyanates can produce hydrogen cyanide gas in a fire. Excessive heat or fire could rupture the pressurized cylinders of polyurethane components used for application on ventilation controls. Also, there is a possibility of spontaneous combustion if this system is sprayed too thick in one pass. Maximum recommended thickness for one application is 2 inches. These and other fire-related hazards associated with polyurethane foam systems could be minimized if only the amount needed for a particular application was taken underground and used before an additional amount was taken underground.

23. ON LONGWALL DEVELOPMENT OR ON LONGWALL PANELS, FIRE-RESISTANT HYDRAULIC FLUID BE USED IN ELECTRICALLY-POWERED EQUIPMENT UNLESS THE EQUIPMENT IS PROTECTED BY A FIRE-SUPPRESSION SYSTEM.

- BB

The use of fire-resistant hydraulic fluids or fire-suppression devices on electrically-powered equipment is required by 30 CFR 75.1107. However, the fire hazards associated with the use of nonfire-resistant hydraulic fluids and the possibility that a portable, dry chemical fire extinguisher may be inadequate to suppress an equipment fire suggests that more reliable fire suppression might be needed. Some electrically-powered equipment design problems have precluded retrofit of fire-resistant hydraulic systems; therefore, a number of machines do not use fire-resistant hydraulic fluid and rely on a fire-suppression device, i.e. a portable fire extinguisher.

The use of nonfire-resistant hydraulic fluid in electrically-powered equipment on longwall development or on a longwall panel introduces a fire hazard which can be eliminated by the use of fire-resistant hydraulic fluid. Where such fluid can not be used for technical reasons, the hazard can be effectively controlled through the use of a fire-suppression system that is either automatically or manually activated.

24. ON ALL LONGWALL DEVELOPMENT AND LONGWALL PANELS, WHERE THE MINE WATER SYSTEM IS USED FOR FIRE FIGHTING AND/OR FIRE SUPPRESSION, THE WATER SYSTEM BE PROVIDED WITH AN UNINTERRUPTABLE POWER SOURCE. - BB

A continuous flow of water is necessary to suppress and control a fire. Ideally, a continuous supply of water for fire-suppression systems on any longwall development or longwall panel can be provided by a gravity-fed system. If a pump system is used, consideration must be given to the source of power. When the pump is electrically driven, a separate circuit should be provided that originates on the surface and can remain energized when all other underground power needs to be disconnected. This circuit must have short circuit and ground fault protection, but motor overload protection should be omitted. A back-up power supply could also be considered acceptable.

NOTE: When the mine water supply system is also used for fire fighting, proper pump motor overload protection is required. But, when this system is needed for fire fighting, the overloads must be quickly and easily defeatable.

25. IN ALL LONGWALL DEVELOPMENT AND LONGWALL PANELS, FIRE-FIGHTING EQUIPMENT PROVIDED AT FIRE HAZARD LOCATIONS BE PROPERLY MAINTAINED AND BE POSITIONED SUCH THAT THEIR POTENTIAL INVOLVEMENT IN A FIRE OR SMOKE IS MINIMIZED. TO AID IN LOCATING VALVED OUTLETS ON FIRE-SUPPRESSION WATERLINES, FIRE EXTINGUISHERS, AND FIRE HOSES NOT READILY VISIBLE FROM NORMAL TRAVELWAYS, REFLECTIVE SIGNS OR MARKERS SHOULD BE INSTALLED. - BB

Fire-fighting equipment, which becomes involved in smoke or fire, is functionally useless and presents potential burn, asphyxiation, or electric shock hazards to any person who might try to obtain it. Similarly, fire-fighting equipment, which is not easily located or is inaccessible during a fire emergency, may be of little or no fire-fighting value. These devices are only effective in combating a fire during its incipient stage. Relocating poorly situated fire-fighting equipment, with consideration to the nature of the potential fire source and direction and velocity of the ventilation air current, would reduce the potential for involvement of fire-fighting equipment in a fire. Identification of fire-fighting equipment locations by brightly colored and highly visible signs or markings that are kept clean would greatly improve visibility and reduce the time required to locate such equipment.

26. COMMUNICATION SYSTEMS PROVIDED BETWEEN LONGWALL PANELS AND OUTBY AREAS, INCLUDING THE SURFACE, BE DESIGNED AND INSTALLED TO RESIST FAILURE DURING EMERGENCY SITUATIONS. THIS WOULD REQUIRE DESIGN AND INSTALLATION METHODS THAT PROVIDE POSITIVE AND EFFECTIVE MEANS TO INCREASE RELIABILITY. - BB

It is commonly recognized that communication becomes critical in times of emergency. Because of the vulnerability of current systems, it is usually the emergency which causes the communications breakdown. ...

Currently, all mine communications systems can be rendered inoperable from any number of sources. The interconnecting cables are the weakest link in the system and failure is frequently caused by: sloughing of roof and ribs; being torn down by vehicles or equipment, and roof falls; and being destroyed by fire.

Therefore, it is vital that significant improvements be made to all installations, in order to enhance the reliability and integrity of the system. Methods to achieve the desired results include, but are not limited to:

- a) redundant systems
- b) burying the cables
- c) using armored cables
- d) wireless systems

27. PROVIDE METHANE MONITORING AND AUTOMATIC DEENERGIZATION OF ELECTRICAL EQUIPMENT WHEN CONDITIONS EXIST WHERE METHANE GAS COULD BE BACKED UP THE INTAKE ENTRIES TO POINTS BEYOND THE NORMAL LOCATION OF NONPERMISSIBLE ELECTRICAL EQUIPMENT. THE USE OF PERMISSIBLE EQUIPMENT IN THE PANEL, WHEN THESE CONDITIONS EXIST, WOULD PROVIDE A SUBSTANTIAL MARGIN OF SAFETY. -
BB

Presently, bumps, bounces, outbursts, and other conditions can occur in gassy mines causing explosive mixtures of methane to be backed up intake entries beyond the location of nonpermissible electric equipment such as the section transformer. As future mining progresses to areas under even heavier cover (3500-4000 feet), it is reasonable to assume that these conditions will continue to occur and possibly increase. It becomes difficult to design ventilation and ground control systems that would arrest these conditions. Therefore:

- a) permissible equipment should be used, or
- b) high-voltage (up to 4160 volts) face equipment should be used with the power center located at the mouth of the longwall panel or development, or
- c) methane monitors should be provided at locations which allow sufficient reaction time to deenergize the power before methane inundates nonpermissible equipment.

28. HIGH-VOLTAGE CABLES USED IN LONGWALL MINING NOT BE CUT AND SPLICED AS PANELS ARE DEVELOPED OR THE LONGWALL RETREATS. THE USE OF PLUG AND RECEPTACLE-TYPE CONNECTORS OR EQUIVALENT ARE RECOMMENDED. - BB

It is recognized that high-voltage cable, with splices or plug and receptacle-type connectors for extending or shortening the high-voltage cable in the longwall panels, can provide equal levels of safety, if performed in an ideal manner. However, the investigation conducted by this Task Force has revealed that plug and receptacle-type connectors would provide an overall greater degree of safety and reliability.

It was observed that the number of high-voltage splices used in a typical longwall panel ranged from 10 to 25. It is recognized that connection points in high-voltage circuits must be accomplished with perfection, or problems will develop immediately. One poorly made connection could be the weak link in the system, resulting in failure. Therefore, cables with plugs and receptacles, constructed in a shop environment, have a potential for greater consistency and reliability than splices made in the mine environment under production-oriented conditions.

29. BRANCH AND FEEDER CIRCUITS LOCATED IN LONGWALL DEVELOPMENT AND PANEL ENTRIES BE PROVIDED WITH SENSITIVE GROUND FAULT PROTECTION⁴ AND A GROUND FAULT TEST CIRCUIT. IN ADDITION, ALL POWER CABLES CONDUCTING POWER BETWEEN EQUIPMENT NOT ON A COMMON FRAME, AT VOLTAGE LEVELS IN EXCESS OF 150 VOLTS TO GROUND, BE SHIELDED-TYPE CABLE (EXCLUDING REELED CABLE). -
BB

Trailing cables and feeder cables are normally exposed to extremely harsh conditions and are frequently damaged. The use of shielded cable and sensitive ground fault tripping, will prevent phase-to-phase fault conditions when damage to a cable occurs. Sensitive ground fault protection is commonly used on circuits up to 1000 volts nominal and may be developed for circuits of higher voltages. In order to verify operation of the sensitive ground fault circuit, a test circuit should be used that passes a small amount of current through the ground fault current transformer. This type of test circuit is becoming commonplace on longwall equipment and on conventional face equipment. Also, several mines are using shielded cable exclusively. The use of shielded cable along with sensitive ground fault protection, combined with existing short circuit protection, will substantially increase the margin of safety and reduce the potential of a fire being caused by damaged cables.

⁴See Appendix A.

30. WHEN DIFFERENT VOLTAGE-LEVEL ELECTRICAL CIRCUITS ARE UTILIZED IN A SINGLE PIECE OF ELECTRICAL EQUIPMENT, SUCH AS A POWER CENTER OR LONGWALL CONTROLLER ENCLOSURE, THESE VARIOUS CIRCUITS BE PHYSICALLY ISOLATED FROM EACH OTHER BY BARRIERS TO PREVENT A SHOCK HAZARD. - BB

Many accidents have occurred in which the design of the electrical equipment involved has been a contributing factor. Equipment containing power circuits and control circuits, that are not physically separated or isolated from each other, is frequently involved in electric shock and electrocution accidents. Although there are many regulations and safety precautions dealing with performing work on electrical equipment, accidents of this type are still occurring. Many of these accidents occur when a control or low energy circuit is being worked on while energized (troubleshooting). The person performing this work accidentally comes in contact with an adjacent circuit energized at a much higher voltage. If the equipment were designed in such a manner that this inadvertent contact was physically impossible, many electrical accidents could be prevented.

31. WHEN BELT HAULAGE ENTRIES ON LONGWALL DEVELOPMENTS OR PANELS ARE DESIGNATED AS ESCAPEWAYS, THE BELT BE PROVIDED WITH AN EMERGENCY STOP/PULL CORD, INSTALLED ON THE TRAVELWAY SIDE, FOR THE ENTIRE LENGTH OF THE BELT. WHERE THESE BELTS ARE USED TO TRANSPORT PERSONNEL, THE EMERGENCY STOP/PULL CORD SHOULD BE LOCATED SO AS TO BE ACCESSIBLE FROM BOTH THE BELT AND THE TRAVELWAY. - BB

When escape in the conveyor belt entry is attempted and heavy smoke limits visibility, a danger of stumbling or falling into the conveyor belt exists. If the belt is running, serious injury or death could result. An emergency stop/ pull cord would provide a means for miners attempting escape to stop the belt.

32. THE FOLLOWING OPERATIONAL SAFETY FEATURES ARE RECOMMENDED FOR ALL LONGWALL MINING SYSTEMS:

- (A) THE FACE CONVEYOR BE EQUIPPED WITH A PRE-START ALARM
- (B) THE SHEARER BE EQUIPPED WITH A PRE-START ALARM
- (C) THE PRE-START ALARMS BE DESIGNED TO DETERMINE THAT THE ALARM HAS SOUNDED PRIOR TO ALLOWING START-UP
- (D) POSITIVE LOCKOUT STATIONS FOR THE FACE CONVEYOR BE INSTALLED AT DESIGNATED INTERVALS ALONG THE LONGWALL FACE
- (E) A PULL-CORD TYPE EMERGENCY STOP DEVICE(S) BE INSTALLED ALONG THE ENTIRE LENGTH OF THE FACE CONVEYOR
- (F) A VOICE COMMUNICATION SYSTEM BE PROVIDED ALONG THE ENTIRE LONGWALL FACE, INCLUDING THE MASTER STATION. - BB

Typically, longwall faces range from 400 to 1000 feet in length. Miners are required to work and travel along the complete length of the face. It is physically impossible for any one person to observe all of the activity that takes place during mining operations. Most of the equipment on the face is centrally controlled (started and stopped) from the master control station. This method of operation dictates the need for additional operational safety features to be employed.

The face conveyor runs along the entire length of the face. There should be a positive warning to alert miners that the conveyor is going to start. Otherwise, someone could be on the conveyor when it starts, resulting in injury or death.

The shearer could be interlocked so that starting is accomplished only after the face conveyor is running. This would preclude persons from being around the cutting drums of the shearer during start-up. In essence, the conveyor alarm and operation would serve as a pre-start alarm for the shearer. This alarm should ensure a positive audible signal be sounded or prohibit the conveyor from starting.

There are many times when it becomes necessary to stop the conveyor in order for a person to enter onto the conveyor and perform some minor task. The conveyor should be provided with positive lockout stations, thus enabling this person to assure that the conveyor cannot be started while that person is exposed.

There are also times when something becomes jammed in the conveyor, or for other emergency reasons, that the conveyor must be quickly stopped. Therefore, it is very important to have the capability of stopping the conveyor from anywhere along its entire length, by means of a pull-cord emergency stop device.

Voice communication is vital in order to provide effective and efficient communications to all miners on the face, including the master station operator. Each person must know what is happening, at any given moment, that could affect the mining operation and the safety and security of that person. These things can best be accomplished by a system of positive voice communication.

The final grouping of recommendations addresses potential safeguards which the Task Force believes merit additional study/research. Because of the complexity and/or long-term nature of the work involved, these studies go beyond the scope of the Task Force. However, if this work is successfully completed, the Task Force believes that the safety of the underground workplace will be enhanced. Three of the Task Force's recommendations fall within this category.

33. PARTITIONING OF THE INTAKE ENTRY IN THE TWO-ENTRY SYSTEM TO PROVIDE AN ADDITIONAL ESCAPE ROUTE BE INVESTIGATED. - C

An alternative means of providing the ventilation and escapeway options of the three-entry system may be possible in the partitioning of the two-entry system. By mining the intake entry to a greater width than the return entry, sufficient clearances could be obtained to construct a substantial and noncombustible partition or seal along the length of the intake entry. The partitioning concept has previously been applied in one single-entry experiment. In that application, the single entry was mined to a width of 26 feet and the partition was attached to three-foot-square cribbing. The remaining 23 feet, less the width of the partition, was equally divided into intake and return airways on the longwall development. The intake entry was, therefore, less than 12 feet in width, which resulted in the partition sustaining vehicular damage on several occasions.

If the intake entry of a two-entry system were mined to a width of 26 feet, the partitioned area could be provided with a width of 6 feet as required for an escapeway, leaving 20 feet, less the partition width, for the main haulageway.

Possible damage to the partition would be less likely than was experienced in the previous experiment. The partitioning concept could also be applied to belt isolation in the return of the two-entry system.

The current industry trend is toward adoption of progressive sealing techniques. These methods contain no provision for sealing of the exposed side of each panel gob. By locating the intake entry on the off-side of the panel and by providing a partition constructed as a seal, each panel gob could be immediately and completely sealed upon completion of mining in that panel. The immediate sealing of the panel gobs may be beneficial in mines with spontaneous combustion problems. In those mines using methane drainage systems, the useful life of those systems might be prolonged.

As this partitioning concept has not been applied to the two-entry system, a number of unanswered questions arise. These include the design, composition, and construction of a suitable partition and its stability in steeply pitching seams or conditions of rolling roof. These questions, and others, can best be answered by experimental means. The relative merit of this concept as opposed to other means, such as leaving barriers for sealing purposes, can be more accurately determined within the strict experimental environment. An experimental investigation and evaluation of this concept's potential is warranted and is recommended by the Task Force.

34. UPGRADED FIRE-RESISTANCE STANDARDS FOR CONVEYOR BELTING USED IN LONGWALL DEVELOPMENT OR LONGWALL PANELS BE DEVELOPED. - C

Conveyor belting is required to meet the requirements of 30 CFR, Part 18, Subpart C (Bureau of Mines, Schedule 2G) for fire resistance and acceptability for underground use. The suitability of this test for determining flammability behavior of conveyor belts under actual fire conditions has been questioned. Investigations have shown that certain neoprene and PVC belts that had been approved were capable of propagating flame over their entire length when full-scale conditions were simulated. Large-scale research is needed to upgrade the fire-resistance standards for conveyor belting used in longwall development or longwall panels which would reduce the potential hazards of conveyor belt fires.

35. ENVIRONMENTAL MONITORING SYSTEMS BE APPROVED AND THAT APPROVAL BE ISSUED TO BOTH THE MANUFACTURER AND THE MINE OPERATOR BY MSHA. - C

These approvals would contribute toward ensuring maximum system reliability. At present, design and manufacture of the monitoring systems are based on technology, which is rapidly developing, and cooperation between MSHA and equipment manufacturers is necessary. Performance criteria does not currently exist with which to evaluate monitoring systems and their components. However, once developed, these criteria would benefit mine operators, equipment manufacturers, MSHA, and the miner. The Task Force, therefore, recommends that work on the development of these criteria be initiated as soon as possible. Also, the application and installation of the monitoring system should be reviewed by both the mine operator and MSHA to ensure the most effective sensor and component placement. To assist the operator, several government-sponsored research publications on sensor selection and placement are currently available.

CONCLUDING STATEMENT

Many of the recommendations presented in this report were observed in operation at one or more of the mines visited. Therefore, the Task Force concluded that the recommendations made are technically feasible and can be implemented.

Finally, the Task Force recognizes that implementation of its recommendations is not solely the answer to providing overall safety in longwall mining. A positive attitude toward safety and housekeeping and pride in the workplace is also necessary to ensure a hazard-free environment for the miner. Mine operators, labor, and enforcement personnel must cooperate in reaching this goal.

KEY TO SUMMARY OF RECOMMENDATIONS AND RELATIVE IMPORTANCE

AAA - SAFEGUARD ADDRESSES A CONDITION OR PRACTICE WHICH PRESENTS A SAFETY HAZARD OF SUCH GRAVITY THAT IMMEDIATE ACTION IS WARRANTED.

BB - SAFEGUARD ADDRESSES A POTENTIALLY SEVERE HAZARD WHICH SHOULD BE CONSIDERED ON A CASE-BY-CASE BASIS.

C - THIS RECOMMENDATION ADDRESSES POTENTIAL SAFEGUARDS WHERE ADDITIONAL STUDY AND/OR RESEARCH MAY RESULT IN IMPROVED SAFETY.

SUMMARY OF RECOMMENDATIONS & RELATIVE IMPORTANCE

NO.	SUBJECT OF RECOMMENDATION	2-ENTRY		3 OR MORE ENTRY		
		DEVELOPMENT	RETREAT	DEVELOPMENT	RETREAT	RETREAT
1	TAILGATE EGRESS	---	AAA	---	AAA	AAA
2	BLEEDER PROTECTION	---	AAA	---	AAA	AAA
3	SCSR STORAGE	---	AAA	---	AAA	AAA
4	EMS - INTAKE ESCAPEWAY	AAA	AAA	AAA	AAA	AAA
5	EMS - BELT ENTRY	AAA	AAA	AAA	AAA	AAA
6	DIESEL-POWERED EQUIPMENT	AAA	AAA	AAA	AAA	AAA
7	OVERCASTS & STOPPINGS	AAA	AAA	AAA	AAA	AAA

SUMMARY OF RECOMMENDATIONS & RELATIVE IMPORTANCE

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NO.	SUBJECT OF RECOMMENDATION	2-ENTRY		3 OR MORE ENTRY	
		DEVELOPMENT	RETREAT	DEVELOPMENT	RETREAT
8	TAILGATE SUPPORT - FIRST PANEL	---	BB	---	BB
9	TAILGATE SUPPORT - SUCCESSIVE PANELS	---	BB	---	BB
10	GROUND FAILURE PROCEDURES	---	BB	---	BB
11	DUST - DESIGNATED AREA	BB	---	---	---
12	DUST - DESIGNATED OCCUPATION	BB	---	---	---
13	SECTION TRANSPORTATION	BB	BB	BB	BB
14	ESCAPEWAY FIRE HAZARDS	BB	BB	BB	BB

SUMMARY OF RECOMMENDATIONS & RELATIVE IMPORTANCE

NO.	SUBJECT OF RECOMMENDATION	2-ENTRY		3 OR MORE ENTRY		
		DEVELOPMENT	RETREAT	DEVELOPMENT	RETREAT	RETREAT
15	BATTERY-CHARGING STATIONS	BB	BB	BB	BB	BB
16	PANEL TROLLEY CIRCUITS	BB	BB	BB	BB	BB
17	EMS - TAILGATE ENTRY	---	BB	---	BB	BB
18	EMS - PERFORMANCE EVALUATION	BB	BB	BB	BB	BB
19	ACCEPTABLE SEALANTS	BB	BB	BB	BB	BB
20	EMULSION PUMP STATION LOCATIONS	---	BB	---	BB	BB
21	COMBUSTIBLE LIQUID STORAGE	BB	BB	BB	BB	BB

SUMMARY OF RECOMMENDATIONS & RELATIVE IMPORTANCE

NO.	SUBJECT OF RECOMMENDATION	2-ENTRY		3 OR MORE ENTRY	
		DEVELOPMENT	RETREAT	DEVELOPMENT	RETREAT
22	POLYURETHANE STORAGE	BB	BB	BB	BB
23	HYDRAULIC FLUID	BB	BB	BB	BB
24	FIRE FIGHTING WATER SYSTEM	BB	BB	BB	BB
25	FIRE FIGHTING EQUIPMENT	BB	BB	BB	BB
26	COMMUNICATION SYSTEMS	BB	BB	BB	BB
27	METHANE INUNDATION PROTECTION	BB	BB	BB	BB
28	HIGH-VOLTAGE CABLE CONNECTIONS	BB	BB	BB	BB

SUMMARY OF RECOMMENDATIONS & RELATIVE IMPORTANCE

NO.	SUBJECT OF RECOMMENDATION	2-ENTRY		3 OR MORE ENTRY	
		DEVELOPMENT	RETREAT	DEVELOPMENT	RETREAT
29	GROUND FAULT PROTECTION	BB	BB	BB	BB
30	CIRCUIT ISOLATION IN ELECTRICAL EQUIPMENT	BB	BB	BB	BB
31	BELT EMERGENCY STOP CORD	BB	BB	BB	BB
32	SAFETY FEATURES FOR LONGWALL SYSTEMS	---	BB	---	BB
33	2-ENTRY SYSTEMS - PARTITIONS	C	C	---	---
34	CONVEYOR BELT STANDARDS	C	C	C	C
35	MSHA APPROVAL OF EMS	C	C	C	C

APPENDIX A - Definitions

1. Multiple-entry systems -- method of longwall mining developed with three or more parallel entries.
2. Smokefree -- a mine entry ventilated with intake air and containing no electrical equipment or other potential sources of ignition.
3. Sensitive ground fault protection -- protective devices which limit ground fault current to less than 100 milliamperes.

APPENDIX B - Major Electrical Installations

Examples of major electrical installations

(A) Underground substations consisting of any combination of transformers, disconnect switches, circuit breakers, power factor correction, etc. and supply power for:

- (1) distribution throughout the mine
- (2) longwall panels
- (3) continuous miner sections
- (4) underground shops
- (5) belt drives
- (6) pumping stations
- (7) trolley rectifiers

(B) Belt drives consisting of the motor control equipment, drive motors, power factor correction, auxiliary devices, etc. are:

- (1) panel belt drive
- (2) section belt drive
- (3) mid-point booster belt drive
- (4) main belt drive

(C) Pumping stations consisting of the motor control equipment, pump motors, power factor correction, auxiliary devices, etc. are:

- (1) main mine dewatering pumps
- (2) mine water pumps for firefighting
- (3) mine water pumps for mining equipment
- (4) permanent longwall emulsion pumping stations
- (5) air compressor stations

Rationale:

Ideally every fire source located in the mine should be vented to the return, enclosed in a fire-resistant area, and equipped with a fire-suppression system. In order to be realistic and actually apply the above safeguards, a common sense approach is needed.

The factors used to evaluate these fire sources are how often the equipment is moved, whether or not miners are working in direct association with the equipment, and the location of the equipment.

The working face is constantly moving and to require the fire sources in this area to have the above safeguards is quite difficult. Therefore, the electric equipment located on and in proximity to the working section should not be considered as major electrical installations. To further amplify this concept, if the electrical load (utilization equipment) is advancing or retreating, then the last transformer supplying power to this equipment is not considered as a major electrical installation. In addition, this area is manned during production, providing for early detection of a fire, and can be evacuated quickly to outby areas. The only exception is battery charging in the working face. This equipment is addressed in another area of this report.

Small gathering pumps for dewatering are located throughout the mine and are typically in fixed locations for long periods of time. The pumps are usually less than 25 horsepower and are small enough to be handled by a mechanic and placed in a waterhole. In order to perform the most efficient dewatering in all types of geology, the above safeguards cannot always be applied. The power center supplying any number of pumps is to be considered as a special case and, at least, placed in a fire-resistant area and, where practical, should be vented to a return.

APPENDIX C -

COMPOSITE LIST OF TECHNICAL RECOMMENDATIONS

1. FOR ALL LONGWALL MINING OPERATIONS, A SAFE TRAVELWAY, UNDER SUPPORTED ROOF THROUGH TAILGATE ENTRIES OR BLEEDERS TO A MINE EXIT, BE PROVIDED OFF THE FACE ON THE TAILGATE SIDE FOR EMERGENCY PURPOSES AT ALL TIMES WHILE PERSONNEL ARE PRESENT. TO VERIFY THAT TRAVELABILITY IS MAINTAINED, A WEEKLY EXAMINATION OF THIS TRAVELWAY IS RECOMMENDED.
2. BLEEDER ENTRIES BE PROTECTED BY ADEQUATE SUPPORT PILLARS AND/OR BARRIER PILLARS AND BE MAINTAINED TO ENSURE ADEQUATE VENTILATION AND METHANE CONTROL IN GOB AREAS AND ASSOCIATED ENTRIES.
3. ONE-HOUR, SELF-CONTAINED SELF-RESCUERS (SCSRs) BE CARRIED BY EACH PERSON ON A LONGWALL PANEL OR THAT SCSRs BE STORED NEAR THE STAGE LOADER AND ON OR NEAR THE FACE ON THE TAILGATE SIDE OF ALL LONGWALL PANELS. WHEN THE TIME REQUIRED TO TRAVEL ACROSS A LONGWALL FACE BECOMES EXCESSIVE, SCSRs BE STORED AT LOCATIONS ALONG THE LONGWALL FACE.
4. AN ENVIRONMENTAL MONITORING SYSTEM BE INSTALLED IN THE INTAKE ESCAPEWAY OF ALL LONGWALL DEVELOPMENTS AND LONGWALL PANELS WHEN BOTH DESIGNATED ESCAPEWAYS ARE VENTILATED BY ONE CONTINUOUS SPLIT OF AIR. THE SENSING DEVICES IN THIS MONITORING SYSTEM BE LOW-LEVEL CARBON MONOXIDE MONITORS OR SENSORS FOR ANOTHER PRODUCT-OF-COMBUSTION THAT ARE NO LESS EFFECTIVE.

5. AN ENVIRONMENTAL MONITORING SYSTEM BE INSTALLED IN THE BELT HAULAGE ENTRY WHENEVER BELT AIR IS USED TO VENTILATE ACTIVE WORKING PLACES OR THE BELT ENTRY IS USED AS A RETURN AIRCOURSE. THIS SYSTEM SHOULD UTILIZE LOW-LEVEL CARBON MONOXIDE MONITORS OR SENSORS FOR ANOTHER PRODUCT-OF-COMBUSTION THAT ARE NO LESS EFFECTIVE IN BOTH CASES. ADDITIONALLY, WHEN THE BELT HAULAGE ENTRY IS USED AS A RETURN AIRCOURSE, METHANE MONITORS BE USED.

6. ALL DIESEL-POWERED EQUIPMENT, OPERATED ON ANY LONGWALL DEVELOPMENT OR LONGWALL PANEL WHERE BOTH THE INTAKE AND ALTERNATE ESCAPEWAYS ARE VENTILATED WITH THE SAME CONTINUOUS SPLIT OF AIR, BE APPROVED UNDER THE PROVISIONS OF 30 CFR, PART 36 AND BE PROVIDED WITH A FIRE-SUPPRESSION SYSTEM.

7. OVERCASTS AND STOPPINGS ON ALL LONGWALL DEVELOPMENT AND LONGWALL PANELS BE STRUCTURALLY EQUIVALENT TO AN 8-INCH HOLLOW-CORE CONCRETE BLOCK STOPPING WITH MORTARED JOINTS, AS PER ASTM E-72 OR EQUIVALENT, AND PROVIDE A MINIMUM FIRE RESISTANCE OF 1 HOUR, AS PER ASTM E-119 OR EQUIVALENT.

8. FOR EACH GROUP OF SUCCESSIVE LONGWALL PANELS, UNLESS MINING CONDITIONS DICTATE OTHERWISE, SYSTEMATIC SUPPLEMENTAL SUPPORT BE INSTALLED THROUGHOUT THE TAILGATE ENTRY OF THE FIRST LONGWALL PANEL PRIOR TO MINING THAT PANEL.

9. UNLESS MINING CONDITIONS DICTATE OTHERWISE, SYSTEMATIC SUPPLEMENTAL SUPPORT FOR TAILGATE ENTRIES OF SUBSEQUENT LONGWALL PANELS BE INSTALLED IN ADVANCE OF THE FRONTAL ABUTMENT STRESSES OF THE ADJACENT PANEL BEING MINED.
10. PROCEDURES BE FORMULATED BY THE OPERATOR THAT ADDRESS THE ACTIONS TO BE TAKEN BY THE COMPANY SHOULD THE TAILGATE TRAVELWAY BE CLOSED DUE TO AN UNPLANNED GROUND FAILURE.
11. THE DESIGNATED AREAS FOR RESPIRABLE DUST SAMPLING INCLUDE LOCATIONS IN THE BELT/RETURN AIRCOURSE OF ALL TWO-ENTRY LONGWALL PANELS DURING DEVELOPMENT. ONCE DESIGNATED, THESE AREAS BE SAMPLED FOR THE ENTIRE TIME THE PANEL IS BEING ADVANCED.
12. THE ASSIGNMENT OF THE DESIGNATED OCCUPATION BE BASED ON RESPIRABLE DUST SAMPLING OF EACH FACE OCCUPATION ON EACH TWO-ENTRY DEVELOPMENT.
13. FOR ALL PERSONNEL ON THE SECTION, TRANSPORTATION BE MAINTAINED NEAR THE SECTION FOR ALL LONGWALL SYSTEMS AND LONGWALL DEVELOPMENT PANELS.
14. OFF-PANEL STORAGE AREAS FOR COMBUSTIBLE LIQUIDS AND ALL MAJOR ELECTRICAL INSTALLATIONS LOCATED IN THE INTAKE ESCAPEWAYS BE PROVIDED WITH:

- (A) A POSITIVE MEANS OF VENTILATION DESIGNED TO CARRY PRODUCTS OF COMBUSTION DIRECTLY INTO A RETURN AIR-COURSE,
- (B) A LOCATION HAVING A MINIMUM OF ONE-HOUR FIRE RESISTANCE, AND
- (C) AN AUTOMATIC FIRE-SUPPRESSION SYSTEM THAT IS MONITORED FOR OPERATION.

15. BATTERY-CHARGING STATIONS ON LONGWALL DEVELOPMENT AND PANELS WHERE BOTH ESCAPEWAYS ARE VENTILATED WITH THE SAME CONTINUOUS SPLIT OF AIR BE:

- (A) LOCATED IN A FIRE-RESISTANT AREA,
- (B) EQUIPPED WITH A FIRE-SUPPRESSION SYSTEM, AND
- (C) WHERE A RETURN AIRCOURSE IS AVAILABLE, VENTED DIRECTLY INTO THE RETURN OR, WHEN A RETURN AIR-COURSE IS NOT AVAILABLE, MONITORED BY A SUITABLE FIRE-DETECTION SYSTEM.

16. TROLLEY CIRCUITS LOCATED ON THE LONGWALL PANEL INTAKE ESCAPEWAY BE ENERGIZED FOR SET-UP AND RECOVERY OF THE LONGWALL MINING SYSTEM ONLY.

17. WHEN THE TAILGATE ENTRY IS USED AS A RETURN AIRCOURSE, THE TAILGATE ENTRY, AT A POINT JUST INBY THE INTERSECTION OF THIS AIR-COURSE AND THE MAIN AIRCOURSE, BE MONITORED FOR CARBON MONOXIDE AND METHANE CONTENT.

18. ENVIRONMENTAL MONITORING SYSTEMS BE PERIODICALLY EVALUATED FOR PERFORMANCE.

19. SEALANTS APPLIED TO VENTILATION CONTROL STRUCTURES HAVE A FLAME-SPREAD INDEX OF 25 OR LESS, AS PER ASTM E-162 OR EQUIVALENT. SEALANTS APPLIED TO COAL SURFACES TO MEET THE FIREPROOFING REQUIREMENTS OF 30 CFR 75.1105 BE APPLIED IN, OR EXCEED, THE MINIMUM THICKNESSES FOR THAT SEALANT.

20. HYDRAULIC FLUID (EMULSION) PUMP STATIONS BE LOCATED IN STRUCTURES WITH WALLS HAVING A MINIMUM 1-HOUR FIRE RESISTANCE, AS DETERMINED BY ASTM E-119 OR EQUIVALENT. NO SUCH PUMP STATIONS BE LOCATED ON A 2-ENTRY LONGWALL PANEL.

21. LUBRICATING OIL, GREASE, AND COMBUSTIBLE LIQUIDS NOT EXCEED A 1-DAY SUPPLY ON ANY LONGWALL DEVELOPMENT OR LONGWALL PANEL. DIESEL FUEL NOT BE STORED ON 2-ENTRY PANELS.

22. NO UNDERGROUND STORAGE OF POLYURETHANE BE PERMITTED. THIS APPLIES TO BOTH HIGH-DENSITY POLYURETHANE USED FOR ROOF STABILIZATION AND TO LOW-DENSITY POLYURETHANE USED AS A SEALANT.

23. ON LONGWALL DEVELOPMENT OR ON LONGWALL PANELS, FIRE-RESISTANT HYDRAULIC FLUID BE USED IN ELECTRICALLY-POWERED EQUIPMENT UNLESS THE EQUIPMENT IS PROTECTED BY A FIRE-SUPPRESSION SYSTEM.

24. ON ALL LONGWALL DEVELOPMENT AND LONGWALL PANELS, WHERE THE MINE WATER SYSTEM IS USED FOR FIRE FIGHTING AND/OR FIRE SUPPRESSION, THE WATER SYSTEM BE PROVIDED WITH AN UNINTERRUPTABLE POWER SOURCE.

25. IN ALL LONGWALL DEVELOPMENT AND LONGWALL PANELS, FIRE-FIGHTING EQUIPMENT PROVIDED AT FIRE HAZARD LOCATIONS BE PROPERLY MAINTAINED AND BE POSITIONED SUCH THAT THEIR POTENTIAL INVOLVEMENT IN A FIRE OR SMOKE IS MINIMIZED. TO AID IN LOCATING VALVED OUTLETS ON FIRE-SUPPRESSION WATERLINES, FIRE EXTINGUISHERS, AND FIRE HOSES NOT READILY VISIBLE FROM NORMAL TRAVELWAYS, REFLECTIVE SIGNS OR MARKERS SHOULD BE INSTALLED.

26. COMMUNICATION SYSTEMS PROVIDED BETWEEN LONGWALL PANELS AND OUTBY AREAS, INCLUDING THE SURFACE, BE DESIGNED AND INSTALLED TO RESIST FAILURE DURING EMERGENCY SITUATIONS. THIS WOULD REQUIRE DESIGN AND INSTALLATION METHODS THAT PROVIDE POSITIVE AND EFFECTIVE MEANS TO INCREASE RELIABILITY.

27. PROVIDE METHANE MONITORING AND AUTOMATIC DEENERGIZATION OF ELECTRICAL EQUIPMENT WHEN CONDITIONS EXIST WHERE METHANE GAS COULD BE BACKED UP THE INTAKE ENTRIES TO POINTS BEYOND THE NORMAL LOCATION OF NONPERMISSIBLE ELECTRICAL EQUIPMENT. THE USE OF PERMISSIBLE EQUIPMENT IN THE PANEL, WHEN THESE CONDITIONS EXIST, WOULD PROVIDE A SUBSTANTIAL MARGIN OF SAFETY.

28. HIGH-VOLTAGE CABLES USED IN LONGWALL MINING NOT BE CUT AND SPLICED AS PANELS ARE DEVELOPED OR THE LONGWALL RETREATS. THE USE OF PLUG AND RECEPTACLE-TYPE CONNECTORS OR EQUIVALENT ARE RECOMMENDED.

29. BRANCH AND FEEDER CIRCUITS LOCATED IN LONGWALL DEVELOPMENT AND PANEL ENTRIES BE PROVIDED WITH SENSITIVE GROUND FAULT PROTECTION AND A GROUND FAULT TEST CIRCUIT. IN ADDITION, ALL POWER CABLES CONDUCTING POWER BETWEEN EQUIPMENT NOT ON A COMMON FRAME, AT VOLTAGE LEVELS IN EXCESS OF 150 VOLTS TO GROUND, BE SHIELDED-TYPE CABLE (EXCLUDING REELED CABLE).

30. WHEN DIFFERENT VOLTAGE LEVEL ELECTRICAL CIRCUITS ARE UTILIZED IN A SINGLE PIECE OF ELECTRICAL EQUIPMENT, SUCH AS A POWER CENTER OR LONGWALL CONTROLLER ENCLOSURE, THESE VARIOUS CIRCUITS BE PHYSICALLY ISOLATED FROM EACH OTHER BY BARRIERS TO PREVENT A SHOCK HAZARD.

31. WHEN BELT HAULAGE ENTRIES ON LONGWALL DEVELOPMENTS OR PANELS ARE DESIGNATED AS ESCAPEWAYS, THE BELT BE PROVIDED WITH AN EMERGENCY STOP/PULL CORD, INSTALLED ON THE TRAVELWAY SIDE, FOR THE ENTIRE LENGTH OF THE BELT. WHERE THESE BELTS ARE USED TO TRANSPORT PERSONNEL, THE EMERGENCY STOP/PULL CORD SHOULD BE LOCATED SO AS TO BE ACCESSIBLE FROM BOTH THE BELT AND THE TRAVELWAY.

32. THE FOLLOWING OPERATIONAL SAFETY FEATURES ARE RECOMMENDED FOR ALL LONGWALL MINING SYSTEMS:

- (A) THE FACE CONVEYOR BE EQUIPPED WITH A PRE-START ALARM
- (B) THE SHEARER BE EQUIPPED WITH A PRE-START ALARM
- (C) THE PRE-START ALARMS BE DESIGNED TO DETERMINE THAT
THE ALARM HAS SOUNDED PRIOR TO ALLOWING START-UP
- (D) POSITIVE LOCKOUT STATIONS FOR THE FACE CONVEYOR BE
INSTALLED AT DESIGNATED INTERVALS ALONG THE LONGWALL
FACE
- (E) A PULL-CORD TYPE EMERGENCY STOP DEVICE(S) BE INSTALLED
ALONG THE ENTIRE LENGTH OF THE FACE CONVEYOR
- (F) A VOICE COMMUNICATION SYSTEM BE PROVIDED ALONG THE
ENTIRE LONGWALL FACE, INCLUDING THE MASTER STATION.

33. PARTITIONING OF THE INTAKE ENTRY IN THE TWO-ENTRY SYSTEM TO
PROVIDE AN ADDITIONAL ESCAPE ROUTE BE INVESTIGATED.

34. UPGRADED FIRE-RESISTANCE STANDARDS FOR CONVEYOR BELTING USED
IN LONGWALL DEVELOPMENT OR LONGWALL PANELS BE DEVELOPED.

35. ENVIRONMENTAL MONITORING SYSTEMS BE APPROVED AND THAT
APPROVAL BE ISSUED TO BOTH THE MANUFACTURER AND MINE OPERATOR BY
MSHA.